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UNIVERSITY EDUCATION IN NATURAL SCIENCE

THE problems of education in science and of education through natural science were considered by scientific men and schoolmasters at the Dundee meeting of the British Association, and similar problems at the university level have now arisen in the University of Cambridge. A 'Syndicate' has been reviewing the regulations for the Natural Sciences Tripos, and the discussion of its report in the Regent House on February 22 showed that many in Cambridge have misgivings about the scientific education now being given to undergraduates. A number of tutors, directors of studies and college supervisors urged the need for drastic reforms. The position at Cambridge is probably similar to that at many other British universities, and merits the attention of all who are interested in the training of scientific men and citizens. Many of those who are closely in touch with the life and work of undergraduates are convinced that science students are being given so much formal factual teaching that they have no time for reading and reflexion. The study of the wider and more cultural aspects of their work is precluded and their intellectual development retarded. The courses of instruction seem generally designed for the production of specialist research workers; and specialization seems on the increase, in spite of the fact that only a small percentage of the students who read science become professional scientific workers. It seems to be overlooked that many will become teachers in schools, some will go into the Civil Service, others will join the administrative staffs of business or manufacturing firms; such students need a wider and more general training.

The present position in the universities of Great Britain has grown up gradually, often in the absence of any definite policy to guide the planning of the instruction given. In the past, the content of university courses in natural science was much smaller and there was less specialized science-teaching in the schools; students possessed some knowledge of the art of reasoning either through a study of elementary logic or, at least, through several years of regular lessons in Euclid. But the steady progress of scientific discovery has led to an enormous increase in the fields which students are expected to cover; both at school and at the university, philosophical instruction has been largely replaced by practical training. To-day a good memory rather than a well-trained mind seems to be the key to success. As a result, a science student may gain a high place in examinations, and yet be a very ignorant person when compared with many students of the humanities; and it has been said that the outside activities of young scientific men often show lamentable absence of that spirit of critical inquiry and resistance to propaganda which might be expected in those trained in exact knowledge.

Science students form a large proportion of the present undergraduate population of Great Britain, and they should contribute much to the future intellectual life of the country. We cannot afford to

tolerate a system which produces a mass of narrow specialists for the sake of the few who may become workers in a particular scientific field. Graduates in science should have the well-trained minds and the breadth of vision which will enable them to take up administrative posts or to teach the principles of scientific thought in schools, as well as the details of some branches of scientific knowledge culled from text-books or from their lecture notes.

With the introduction into the schools of the new examination for a General Certificate of Education, it will probably be necessary for many university syllabuses to be revised. When this revision occurs, it is to be hoped that the question of education through science will receive careful consideration. Every university should provide some instruction in the methods of scientific thought and procedure—the grammar of science. How many of our undergraduates could to-day show the use of inductive and deductive reasoning in the subjects which they are studying, or give examples of hypotheses the reliability of which depends on the truth of postulates? A training in the methods used to discover the truth about the phenomena of Nature should teach the student how to try to discriminate between truth and falsehood in the ordinary affairs of life. Some knowledge of the history of science is also of considerable importance; not the kind of history which consists mainly of the dates when significant discoveries were made, with short biographies and anecdotes of great men of science, but a study of the historical background of science. Something of real educational value could be obtained from a knowledge of what men thought about Nature in the past, of the problems which confronted the natural philosophers, of the methods used for investigating these problems, and the difficulties which had to be met owing to imperfect apparatus, faulty observation or mistaken pre-suppositions. It is not suggested that the whole field should be covered, but only selected periods or subjects connected with the student's main lines of study. Lieut.-Colonel H. D. Anthony's book, "Science and its Background" (reviewed in *Nature* of September 4, 1948), shows that such a study can be made both interesting and useful; this mode of approach ought to be further developed at a university level. Sir William Dampier's "A History of Science" (Camb. Univ. Press), of which a fourth edition has recently appeared, is a standard work which must also be considered. An educated man of science should have some knowledge of the part which his own branch of study has played in shaping the material, intellectual and social progress of mankind. Many schoolmasters have realized the educational value of teaching about the operation of scientific progress as the greatest factor in the making of the modern world, but comparatively few young men who have taken university courses in science are competent, on leaving the university, to take an effective share in such teaching.

The problems of specialization also need close study. Too often a high degree of specialization in science begins at school, and no new subjects are studied at the university. This may set the student upon a path which he is not fitted to follow, and it often limits his education both as a citizen and as a man of science. The man who has only been trained in the physical sciences may fail to grasp the problems which arise when scientific methods are applied to heterogeneous living populations; on the other hand, the student without a training in physics and chemistry may well be incapable of following modern experimental work in biology.

The reorganisation of university teaching along the lines which have been suggested will not be easy. It is not merely a question of introducing new courses into an already over-loaded time-table. The whole scheme of instruction needs review, with particular reference to the teaching of students during their first two years at a university. There may be considerable reluctance in some places to consider changes in the long-established routine; but it is vital to the nation that the thousands of men and women now studying science should be trained in the best possible manner. These students will in time become responsible for the progress of scientific knowledge, for our health, our food and for the education of our children; they will contribute to the administration of factories and commercial undertakings; some of them will become Civil Servants, politicians and journalists. It is vital to ensure that students are imbued with a desire to ascertain truth by scientific reasoning, in order to fit them to give of their best in a world which is being deluged with propaganda of every kind.

PERSONAL AND HUMAN FACTORS IN INDUSTRY

Teamwork in Industry

By F. J. Burns Morton. Pp. xii+273. (London: Chapman and Hall, Ltd., 1948.) 18*s*. net.

THIS book in essence is an essay on the theme of leadership, in the sense of which Arthur Bryant wrote in "Years of Victory", of evoking the will to serve rather than a mere matter of transmitting orders. "Unless we can discover and implement," writes Mr. Burns Morton, "means to ensure that men work willingly and harmoniously together, our industrial efficiency will diminish, and with it our trade in the home and foreign markets." The book is frankly a contribution to the thinking and organisation which are indispensable factors in removing the present threat to our industrial future. The approach is pragmatic but fundamental, and Mr. Morton will clearly judge the worth of his work by the extent to which it contributes to the solution of what is now generally admitted to be the key problem in productivity—the establishment of right human relations in industry.

Mr. Morton is fully aware, with Dr. Mayo and such leaders in the theory of scientific management as Mary Follett, Colonel L. Urwick and Sir C. C. Renold, that such relations involve society as a whole as well as the relations between management and the operatives within an industry. With his purpose of stimulating thought rather than offering cut-and-dried solutions to particular problems, Mr. Morton directs his readers to most of the more stimulating and accessible earlier works in this field. There are, indeed, a few surprising omissions, and sometimes he

asks rather much of his reader. A chemist, for example, might perhaps locate the late Prof. C. H. Lander's Melchett Lecture in the *Journal of the Institute of Fuel* without much difficulty; but the ordinary reader may well be at a loss for a clue in either time or space, if he wishes to verify or amplify Mr. Morton's brief quotation.

In his twelve chapters he ranges over such subjects as the human factor, team-work, job satisfaction, selection, training, incentives, leadership, supervision, discipline and social organisation. He starts by examining the causes of present difficulties, and passes in turn to review the social and economic changes which have taken place, to question the suitability of old methods for new problems and to outline the character of human behaviour. Here he insists on a change in policy or some adjustment in administration, there some modification in organisation or the introduction of new methods; throughout he insists on the necessity for training, from executives downwards, for more research in social psychology and industrial management, and for a widespread appreciation of human behaviour.

It would be easy to criticize some of Mr. Morton's observations as platitudinous; and some of the principles he emphasizes are well known, and are conspicuous in the planning that lay behind the successful operations of the War. Such criticism would be unjustifiable. Far too many of the precepts here displayed are still commonly ignored in industry. Moreover, Mr. Morton has here restated more incisively, in a form much freer from jargon and more attuned to British ears, much that is to be found in more diluted form in the vast American literature of management.

As the title of his book suggests, Mr. Morton sees the solution to our problem of productivity in the creation of team-work in industry. This he regards as a spontaneous reaction to environment and circumstances, secured voluntarily and not imposed from above; inspired by example in leaders, it is likely to follow rather than precede collaboration in the executive. It is concerned with external as well as internal relationships, and is a technique applicable primarily to the executives and not to be left to the single influence of a personnel manager. It can be developed by suitably planned measures and should not be left to chance. Its purpose, like that of management, is to make the most use of the man-power available.

The truth of Mr. Morton's diagnosis could easily be demonstrated in the experience of nationalized industry in Britain over the last two years. There the fundamental problem of human factor in industry—Can men be induced to strive efficiently as individuals and to work effectively as a group?—is still unsolved. He would be a bold man who would contend that the National Coal Board has yet succeeded in creating the circumstances which encourage men to do as much as they can instead of as little as they must. It is equally clear that nationalized industry, no more than private industry, cannot confine its attention to problems of production and neglect for long its social obligations without risk of unfavourable reactions. It is still true, as Mr. Morton observes, that competition is necessary; it is the conditions under which competition operates that decide its value.

The book abounds in suggestive observations. Have we yet realized the implications of the vast difference between the casual attention of the repetition worker and the absorbed interest of the skilled technician? This may only be a variation on the theme of craftsmanship, but it bears closely not merely on the creation of co-operation and team-work, but also on selection, the satisfaction a man finds in his job, on training, and on the negative as well as the positive aspect of incentives. Again, how obvious are the principles for giving orders which he lays down in his chapter on supervision, but how often they are ignored! Mr. Morton rightly holds that we need to examine the whole process of giving orders, to build up a technique for the use and guidance of executives in making themselves more effective and their subordinates more efficient.

This is but one of many suggestions for investigation or even research which Mr. Morton makes. On all these subjects he writes with insight, and nowhere more than on the problem of leadership and the conditions in which it can function. False ideas on such matters as joint production committees are dispelled, and if Mr. Morton lays the chief responsibility on the executives of industry for creating the conditions in which effective team-work is possible, he indicates what else is required, and the contribution to be made by trade unions and other bodies. A wise policy in which the idea of service is clearly to be seen can do much to evoke the response required from all engaged in the industry or firm; and this book can make a valuable contribution to the thought on which such a policy must be based and the constructive action required at so many points to deal with the problems arising out of human relations in all phases of industry and at all levels.

R. BRIGHTMAN

A REFLEXION OF SCIENTIFIC AND TECHNICAL PROGRESS

A Century of Book Publishing, 1848–1948

Pp. vii + 74 + 12 plates. (New York and Toronto: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1948.)

A HUNDRED years ago David Van Nostrand opened his bookshop in New York. Many of the customers were his personal friends, who came to discuss with him the merits of the latest books; and in a few years his office became more like a literary club than the bookshop of to-day. So popular was it that in five years he was obliged to move to more spacious quarters.

During a stay in New Orleans, Van Nostrand had come into contact with a group of distinguished army officers, and it is thus not surprising that when he opened his New York office there was a preponderance of military books, especially as the Mexican War had stimulated public interest in military history. At that time the functions of publisher and bookseller were not distinct, and as few technical books were written in the United States, the greater part of the business consisted of selling imported texts of high repute.

Van Nostrand soon became the largest dealer in scientific and technical books in New York, and then proceeded to extend his activities by publishing books which reflected the main interests of the period; thus some of the earliest, in the prospecting days, dealt with the mineral resources of the country. The threat of civil war gave an immense impetus to the demand for military and naval books, and Van Nostrand, appointed official publisher, issued a group which became classics.

From 1860 onwards, a new theme became apparent. This was engineering. Railway engineering was the subject of many notable books when railways and steel bridges were in course of development, but in the middle 90's this gave way to the rapidly growing science of electrical engineering. Civil engineering staged a revival about 1910, and was followed by mechanical engineering. Along with engineering, chemistry came to the fore, and works on the subject expanded at a remarkable rate. Nineteen books were listed in 1884, and more than two hundred in 1948. Not only the numbers but also the size increased. Scott's "Standard Methods" started with 870 pages in 1917 and the present fifth edition has 2,700. Chemistry received its main stimulus from the First World War, but it was not until 1925 that physics showed signs of expansion. In this case the chief development was due to the Second World War, the peak rate of production being reached in 1942 by a text-book on ultra high-frequency technique which was written in sixty days. 3,000 copies were reproduced by the offset process in 37 days and sold almost immediately. In two years 60,000 copies were sold.

The volume under review does not deal only with books; it gives an intimate picture of the working of the Company from the time when a normal edition was 1,000 copies, sold for more than twice their cost of production, to the present day with its planning and fierce competition. The personalities and achievements of the directors are set out at length, and it is difficult to avoid comparing David Van Nostrand at his roll-top desk discussing books with his customers by lamp-light, with the present group of distinguished men directing sales to unknown buyers. Is what we call progress really a measure of happiness?

H. E. WATSON

ECOLOGY OF POTATO VIRUSES AND THEIR INSECT VECTORS

The Spread of Virus Diseases in the Potato Crop

By J. P. Doncaster and P. H. Gregory. (Agricultural Research Council Report Series No. 7.) Pp. 189. (London: H.M. Stationery Office, 1948.) 5*s*. net.

THIS is a substantial piece of work, born of war-time anxiety over possible inadequacy of potato seed supplies for necessary expansion in the acreage devoted to this crop. English growers import each year, from Scotland and Northern Ireland, enough seed to plant half their acreage. This is biennially discarded in favour of a 'change of seed'. There is no doubt about the general wisdom of this policy; but it is equally certain that many discarded stocks could have been grown for more than two years without serious deterioration.

An investigation of this possibility forms one of the major subjects of the present inquiry. We know that the spread of virus diseases, and particularly leaf-roll and rugose-mosaic or crinkle, brings degeneration of the stock. We have the results of numerous laboratory and greenhouse studies on these diseases. We had not, however, until the appearance of this report, an adequate idea of factors which influence the rate of spread of severe virus diseases in the lowland field. We still do not possess any practical method of assessing the suitability for further seed of a crop grown in ware-producing districts. There is a general indication, but a distinct lack of exact correlation, between the amount of virus spread and the numbers of virus-transmitting aphids. There are also incalculable variations between crop and crop.

A major portion of the report is devoted to the actual portrayal of results gathered faithfully by the authors and numerous collaborators, and condensed to intelligible proportions by the text-figures and appendixes. Of the four species of aphids regularly occurring on the potato crop—*Myzus persicæ*, *Aphis rhamni*, *Macrosiphum solanifolii* and *Aulacorthum solani*—the last two mentioned are deemed to play little part in transmitting leaf-roll and rugose-mosaic in the field. *Myzus persicæ* overwinters on peach and *Brassica* crops. A large amount of virus infection is probably accomplished by winged spring migrants; but Apteræ may be partly responsible at the peak of summer infection. *Aphis rhamni* overwinters on *Rhamnus*, though several heavy infections on potatoes have occurred in areas where buckthorn is rare.

The amount of infection within a crop depends far more on the number of diseased plants it contains than upon sources of infection more distant. Survival of diseased volunteer plants may bring about a large increase of virus. Fumigation of large plots with nicotine vapour destroyed the aphids, but had little effect on the spread of rugose-mosaic and leaf-roll. Probably the infection had already been effected much earlier in the year than is commonly supposed. The report, indeed, serves the useful purpose of turning our attention away from the summer maximum of aphids, and concentrating future work on insect-virus relations earlier in the season.

Though the report is somewhat negative with respect to its main target, it contains some very positive contributions along lines which might be called, without disparagement, by-ways to the main investigation. The chapter on development of the potato plant contains a lot of information which is relevant to the question of tuber-size control, now being developed so successfully in some seed-growing areas. The demonstration that a good deal of virus spread occurs much earlier in the year than was suspected may also find its greatest application in seed-growing areas.

J. GRAINGER

PIG PRODUCTION IN GREAT BRITAIN

The Production and Marketing of Pigs

By H. R. Davidson. Pp. xvi + 535 + 96 plates. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1948.) 30*s*. net.

THE British housewife has a weekly reminder of the poverty of the national larder in respect of pig meat; but she is not alone in regretting the recent drastic decline in pig production in Great Britain. Many farmers echo her regrets, and welcome, though cautiously, the signs that the agricultural stage is possibly being set for a real revival of pig-keeping as an essential and profitable part of British livestock industry. That there are now such signs makes this a singularly opportune time for issuing a comprehensive, and not unduly expensive, text-book on pig husbandry; and the opportunity is all the better served if authority in matter is matched with appropriate format, as it is here by Mr. H. R. Davidson and his publishers.

At last it is possible to give almost unqualified appreciation to a book in which the author seriously attempts to present a synthesis of modern work and ideas on nutrition, breeding and economics in relation to the management of a farm animal. From the width, and depth, of his experience as scientific worker and practical farmer, Mr. Davidson recognizes that animal husbandry is not just the sum of the components of breeding, feeding and management, but that the psychology of the animals as well as of their attendants enters into everyday problems and practices of stock-keeping. He recognizes also that the last words on any branch of husbandry are not yet said; he therefore adopts a strictly personal attitude in his treatment of data, observations and experiences, which adds to the usefulness of the book.

The scope is truly comprehensive. Part 1 reviews the general economic background of the British pig industry; it includes a series of analyses of the cost structures of pig enterprises and a particularly apt résumé of the history, and fate, of the pre-war marketing schemes for pigs and their products. Part 2, "Theoretical and Technical Considerations", brings together a mass of information on carcass qualities and trade matters, together with a valuable description of systems of carcass judging and evaluation; it gives a sensible presentation of the plain principles of nutrition, followed by a study of feeding practices, and proceeds to a discussion of the physiological, anatomical, and genetical aspects of pig improvement, and finally, to specific chapters on matters of housing and hygiene. Part 3 is devoted to critical accounts of the practical aspects of management, in which the author's experience is given as a helpful guide to the proper care and handling of pigs of all ages and stages.

The text is well and aptly illustrated by plates and diagrams; relevant data are conveniently tabulated for detailed consultation, or for neglect, at will; there is an extensive and appropriate list of references; and the index is effective. There are some, but only a few, minor typographical errors. Author and publishers have been remarkably successful in making available no mere compilation, but a work which, by reason of its judicial yet personal character and its range, sets a very high standard in literature suited to the needs of the progressive practical stockman, the agricultural student, and the scientific worker, as well as to the needs of the times. J. E. Nichols

RADON AND ITS APPLICATIONS

Radon

Its Technique and Use. By W. A. Jennings and Dr. S. Russ. (Published for the Middlesex Hospital Press.) Pp. x+222. (London: John Murray, 1948.) 18*s*. net.

It is a little difficult on reading this book to decide precisely for what class of reader it was designed. The treatment is, on the whole, elementary; but certain aspects of the subject, particularly those concerned with the technique of extraction, are dealt with in very great detail.

Certainly the first part of the book, where the subject of radioactivity is dealt with generally, will provide an excellent introduction to the non-specialist; and, with its clear exposition of the history of radon and its applications, it will convey to him something of the care essential in the handling of all radioactive substances.

The second part of the book is concerned with the details of the process of radon extraction. Separate chapters are devoted to the radium sources used, the extraction and purifying processes, the loading process, the measurement of gamma-ray activity and, finally, an analysis of the variation of content among groups of radon seeds. The treatment is didactic rather than critical. A wealth of detail is given of particular forms of apparatus, and a large number of numerical examples are given, illustrating methods of control and calculation. The methods described for the preparation of radon seeds are those that were used at the Radon Centre of the Medical Research Council; but little reference is made to the other method now used extensively, where the radon is led directly into gold capillary tubing.

The final section of the book deals with the medical applications of radon. Much of the classical treatment for dosage estimation with radioactive sources is given, and a number of nomograms and other types of graphical methods are described for the estimation of dose in particular techniques. A chapter on "Some Medical Considerations" is contributed by Mr. T. A. Green, whose methods of using radon are described in considerable detail. No attempt is made by the authors in this section to give a general survey of the ways in which radon is used.

Appendixes at the end of the book give some details of the recommendations of the British X-Ray and Protection Committee relating to radon, and some outline proposals for the lay-out of a National Radon Centre. Useful tables are also given of the rise with time of the gamma-ray activity of radon seeds and the hourly growth and decay of radon.

The book is well produced with clear diagrams and tables. The reviewer has noticed one or two small errors in the tables at the end. It contains much valuable information that is not collected together elsewhere; but some readers will regret that the authors chose to confine themselves to a discussion of particular methods and techniques rather than to make a comparison of methods and techniques in general.

ANTHROPOLOGY IN THE SOVIET UNION

Contributions to the Anthropology of the Soviet Union

Compiled by Henry Field. (Smithsonian Miscellaneous Collections, Vol. 110, No. 13: Publication 3947.) Pp. vii+244+5 plates. (Washington, D.C.: Smithsonian Institution, 1948.)

This compilation of the work of Russian archæologists and physical anthropologists covers a period of some ten years. The author is indeed to be congratulated on producing a volume which is absolutely indispensable for all archæologists and physical anthropologists outside the Soviet Union. One of the tragedies of the present world political situation is the lack of contact between Soviet researchers in these sciences and the rest of the world. How far any conclusions reached are coloured by their political theories of to-day cannot be discussed in this review; but certain it is that greater personal contacts would result in a greater understanding, not only of all the fine work which is being

accomplished, but also in the attitudes of mind of researchers to their work.

The continued use of cultural terms—Clacton, Azilian, and the like—for cultures in Russia and the Crimea is also a matter needing discussion. The tendency in the West is to consider that these cultures have no wide distribution and that elsewhere at the same time other, sometimes allied but not identical, cultures occurred. The Gabrielle de Mortillet system was created for the situation in France; it strains and creaks when it is extended to apply to the whole world. Up to the recent War, the Roumanians took their culture in large part from France; but the resulting culture and the people of Roumania were not French. So many of these problems could be settled if greater contact with our Soviet colleagues was possible, and therefore we are indeed grateful to Mr. Henry Field, who has at least, in part, made liaison.

The volume deals first with the archæological situation in the Soviet Union, and later with the physical anthropology. It opens with an account of a conference called by the Academy of Sciences and held in Moscow during 1945, and which was attended by Mr. Field as the delegate of the Smithsonian Institution and other learned bodies in America. There follows an account of more than three hundred Stone Age sites recently investigated. Not all these are of world-shaking importance, of course; but many of them were entirely unknown to students outside the Soviet Union heretofore. The anthropological side, too, has not been omitted, and, besides a general account of recent work on the origin of the various inhabitants, there is a more detailed discussion arranged geographically of the different folk who people that vast area of the world's surface.

Certainly it is a volume to possess, and one can only hope that the author will continue to act as a 'liaison officer' until the happy day dawns when more direct contacts become easier. M. C. BURKITT

VIA SULPHONAMIDE

The Sulphonamides and Allied Compounds

By Dr. Elmore H. Northey. (American Chemical Society, Monograph Series, No. 106.) Pp. xxvii+660. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1948.) 75*s*. net.

THE chemists, Fritz Mietzsch and Joseph Klarer, and the pharmacologist, Gerhard Domagk, all working in the laboratories of the I.G. Farbenindustrie in Wuppertal-Elberfeld, synthetized and tested the first chemical compound to show specific chemotherapeutic protection in mice infected with lethal doses of hæmolytic streptococci. This historic occasion was probably early in 1931, since the German patent covering it is dated November 7, 1931. About a year later, on December 24, 1932, a patent was applied for to cover prontosil rubrum, a more effective compound, and this very great discovery must have taken place earlier in the same year. The first clinical report appears to be that of Dr. Foerster at the monthly meeting of the Dusseldorf Dermatological Society on May 17, 1933, and records the cure of a staphylococcal septicæmia in a ten-month-old boy by the use of prontosil ('Streptozon'). Late in 1935, Tréfouël, Tréfouël, Nitti and Bovet, at the Pasteur Institute, discovered that the chemotherapeutic action of prontosil, and of many similar molecules, was due to *p*-amino-benzene-sulphonamide, a metabolic product of prontosil. They went on to say, "The therapeutic activity of such a simple molecule which is itself not a colouring matter, opens the way to a systematic study of chemotherapy comparable to that which has been followed in the case of pentavalent arsenic". Time has clothed this scientific appraisal in the garb of classical understatement.

Domagk must have appreciated the significance of his great discovery, but he could scarcely have realized that he was ushering in a new era of bacterial chemotherapy. In a short span of twenty years the stimulus has produced important reactions in the allied field of protozoal disease and, in a broader sense of chemotherapy, in the allied fields of non-infectious disease.

By 1939 the literature of sulphonamide drugs had become enormous and the nomenclature chaotic, so that a grateful scientific world welcomed the original Northey review on sulphonamide drugs published in *Chemical Reviews*, 27, 85 (1940). The present monograph is the outgrowth of this review, revised and amplified; the new compounds now number 5,400. The system of nomenclature used in the original review and which received world-wide approval is used in the book, and is that developed by the author in collaboration with Austin M. Patterson. The general classification is a sensible compromise with Beilstein's "Handbuch der organischen Chemie".

There are twelve chapters, the first seven of which describe the nomenclature, classification and synthesis of sulphanilamide derivatives, related derivatives and sulphones. Chapter 8 is by Dr. H. J. White, of the bacteriological department of the Stamford Research Laboratories, and deals capably with the 'standard methods' and their pitfalls. There is a sound helpful chapter (10), by Dr. J. T. Litchfield, on the pharmacology, with special emphasis on absorption and distribution and which reflects, almost audibly, the teachings of the master, E. K. Marshall. There is also a comprehensive clinical survey by Dr. B. W. Carey, of the Lederle Laboratories Division. Chapter 11 is devoted to an unusually complete survey of the theories of the mechanism of action of sulphonamide drugs. The author has some sound and pleasing general observations, and he notes "that all theories are at best mere abstractions from reality which are approximately true under special conditions", and "new fundamental discoveries in the field are usually made by men able to think outside of the prevailing theories, or astute enough to recognize phenomena not conforming to the theories".

The formidable task of reducing to orderly dimensions the very heterogeneous collection of sulphanilamide derivatives and related sulphones is extremely well done. Beginning with a clear and logical nomenclature, some thousands of derivatives are listed and classified, the various categories being tabulated in the table of contents and the index. Having mastered the (simple) rules of Chapter 2, the reviewer made several trial excursions and emerged, to his satisfaction, with the compound sought. A random sample (2 per cent) of the 2,668 references quoted found meticulous accuracy.

The book is well printed on good paper, but the tables are indifferently set; it is expensive.

GEORGE BROWNLEE

British Rainfall 1946

The Eighty-sixth Annual Volume of the British Rainfall Organisation. Report on the Distribution of Rain in Space and Time over Great Britain and Northern Ireland during the Year 1946 as recorded by about 5000 Observers. (Air Ministry : Meteorological Office, M.O.495.) Pp. v+214. (London : H.M. Stationery Office, 1948.) 21*s*. net.

"BRITISH RAINFALL" makes a welcome reappearance after a gap of six years, the latest preceding volume being that for 1939. There are some changes of format, and a number of the maps are missing ; but the essential features, so necessary in planning the best use of water, remain. These include, besides the distribution of monthly, seasonal and annual rainfall and raindays, chapters on dry and wet spells, duration of rainfall, heavy falls, evaporation and percolation ; all are plentifully illustrated by tables, and there are still a good many maps. It is pleasing that the coloured chart of rainfall as a percentage of normal remains. But the text is necessarily curtailed, and well over half the volume consists of the "General Table" giving the annual totals of rain and raindays, and the long-period average rainfall for about 5,000 stations.

The introduction emphasizes that such a vast fund of information is only made possible by the enthusiasm of a large body of voluntary observers, some of whom have maintained their records for many decades. The volume records the deaths of two observers—Sir John Eldon Bankes and the Mackinnon of Mackinnon—of seventy years standing, and seventeen others of more than thirty years. Unfortunately, the "General Table" lacks the records from Eire, which has now its own meteorological service. The data for 1940–45 are to be published shortly in two three-yearly volumes.

New Syllabus Algebra

By C. O. Tuckey and W. Armistead. Pp. viii+201. (Cambridge : At the University Press, 1948.) 5*s*. net ; without Answers, 4*s*. 6*d*. net.

THIS is a really modern book on algebra, designed to cover those parts of the subject which are of special interest and importance. It is based largely upon the recommendations suggested in a report issued in 1944 by a representative conference of examining bodies and teachers. In this report it is stated that "The transition from static mathematics of the formula, which enables one quantity to be calculated when another is known, to the dynamic mathematics of the function, which considers how one thing changes with another, is one of the chief ways in which mathematics has adapted itself to the consideration of practical problems". As the authors point out in the preface, this course of algebra has been "arranged according to the types of function to which various processes are applied instead of the customary division according to types of manipulation". A feeling is thus created for functionality which can be developed at an early age.

The book is divided into three parts : the beginnings ; proportion and linear functions ; squares, areas and quadratics. The new method for factors, given on p. 142, was taught by the reviewer for many years. Its logical conciseness renders it particularly interesting to pupils, and any legitimate method which serves to stimulate interest is manifestly worth while. The method may easily be extended to include cases where the coefficient of x is other than unity. A fundamental place is given to the pupil's concept of functionality by introducing ideas of the gradient and of the derivative of quadratic functions.

The whole course is thoroughly sound and skilfully written, a special feature being the last few pages devoted to topics of algebraical interest, for these will bear out "the desire to bring mathematics more closely into relation with the life and experience of the pupil". Answers are provided, and there is a single-page index. F. G. W. BROWN

The Essential Oils

By Dr. Ernest Guenther. Vol. 1 : History, Origin in Plants, Production, Analysis. Pp. xvi+427. (New York : D. Van Nostrand Co., Inc. ; London : Macmillan and Co., Ltd., 1948.) 33*s*. net.

THIS collaborative work has behind it the resources and experience of Fritzsche Brothers of New York, well known as producers of essential oils. Dr. E. Guenther, a vice-president of the firm, discusses the technique of essential oil distillation, from the broadest principles of the binary distillation diagram down to such details as the effect of pressure differential within the still in liberating the oil from the plant cells. Enfleurage and solvent extraction, and the preparation of terpeneless oils, are illustrated from Messrs. Fritzsche's practice and also from that followed in Grasse and elsewhere. Mr. E. E. Langenau, director of the firm's analytical laboratories, describes in working detail the determination of the analytical characters of essential oils, and the estimation of impurities, adulterants, and constituents of particular importance such as cineole and stearoptene. A director of the American Institute of the History of Pharmacy (Dr. George Urdang) sketches the history of the industry ; and a professor of bio-organic chemistry (Dr. Haagen-Smit) discusses the pure chemistry of the chain- and ring-systems encountered, and the plant physiology of their formation. The section on the functions of the oils in plants offers, perhaps, too many tentative solutions of this question for any of them to seem very satisfying ; analogously to the famous theologian in meditation on the cosmos, the reader may begin to feel that he has learned every possible thing about essential oils except why God created them. The scope outlined for future volumes of the work, however, suggests that even this uncertainty will, in due time, be resolved.

Rhenium

Dvi-Manganese, the Element of Atomic Number 75. By Dr. J. G. F. Druce. Pp. viii+92. (Cambridge : At the University Press, 1948.) 10*s*. 6*d*. net.

THE discovery of rhenium in 1925 was quickly followed by widespread and intensive research on its properties, so that, within seven or eight years, sufficient information had become available to enable several authors to produce monographs on the element. Since then, a considerable amount of further knowledge has been accumulated, so that a new publication is to be welcomed. Dr. J. G. F. Druce should be well qualified to undertake this task, for he has been actively interested in rhenium throughout its history. His monograph covers the subject fairly well and provides a useful summary of the chemistry of the metal and its compounds. Unfortunately, however, it gives the impression of having been hurriedly written. For example, on page 14 a description is given of the systems tungsten–rhenium and phosphorus–rhenium, and this is again repeated on page 66. Furthermore, in describing potassium perrhenate the statement is made (p. 40), "Its density is about

4·89. In toluene, however, Biltz found the value 11·4." This latter value is obviously incorrect and, indeed, has nothing to do with potassium perrhenate, but is, actually, the density of rhenium dioxide. Then again, on page 16, a table is given of the principal lines in the optical spectrum of the element, which is stated to be "by Loring", whereas it is due to W. F. Meggers and is merely quoted by Loring in an article.

At the end of the text there is given a chronological bibliography which the author claims to be complete and to have been compiled with great care. It is, however, not complete and even omits one or two references which have been mentioned in the text. Moreover, the reviewer found at least a dozen errors of one kind or another in it. Nevertheless, the bibliography is very useful and is reasonably complete, particularly with regard to papers dealing with the chemistry of the metal and its compounds. G. R. DAVIES

The Students Handbook to Foundations of Animal Feeding

By L. T. Lowe. Edited by G. H. Purvis. (Published for the Monmouthshire Institute of Agriculture.) Pp. 93. (Worcester: Littlebury and Co., Ltd., 1948.) 8*s*. 6*d*. net.

THIS small book, according to its dust-cover, purports "to provide as concisely as possible essential modern technical and scientific information for those engaged in training and advising agricultural students of all kinds, and especially those at agricultural and horticultural institutes", in which activities author and editor have considerable experience. Unfortunately this reviewer holds the opinion that clarity is preferable to conciseness and repetition, and that punctuation and careful proof correction are essential in even the most elementary scientific texts. Moreover, he also doubts whether acquisition of a patter reflects a thorough appreciation of principles. For these reasons he finds this compilation disappointing. Even if the purpose were to provide only a handy reference, little is gained by adding an eight-page glossary which mainly repeats or paraphrases explanations in the seventy-page text, or by separating "Index, Animal Nutrition" from "Index, Feeding Stuffs". J. E. NICHOLS

Your Body and the Way it Works

By Prof. Winifred Cullis. (Understanding the Modern World Series.) Pp. 32. (London: George Allen and Unwin, Ltd., n.d.) 3*s*. 6*d*. net.

IN her broadcasts to schools and lectures to members of the Armed Forces, as well as in instructional films, Prof. Winifred Cullis has gained an enviable reputation as a popular interpreter of human physiology. In her latest little book she adds to that reputation by successful collaboration with Ian Morrison, an accomplished artist who has also had experience of teaching physiology to young people in school. As in other books in this series, the author expresses herself largely through the artist, each topic being presented visually rather than prosaically. The section dealing with the brain and nerves, for example, contains enough diagrams with suitable legends to enable the young reader to understand the general working of the human nervous system. The diagrams have been ingeniously devised and well drawn in attractive colouring, and should stimulate sufficient interest to lead the reader at once to the accompanying text, which has been clearly thought out to fit in with the diagrams. Particularly fine sections are those dealing with the special senses and reproduction, the latter containing one diagram making crystal clear a point which teachers find so difficult to convey to young students, namely, the exchanges between embryo and mother in the placental circulation where the two blood circulations do not themselves mix. The book also contains a useful supplementary section indicating practical hints of what may be done to test the statements made in other parts of the book. T. H. H.

Photographic Surveying

By Colonel B. B. Talley and Paul H. Robbins. Pp. v+223. (New York, Chicago and London: Pitman Publishing Corporation, 1945.) 24*s*. net.

THIS book has been written as an introduction to the subject for those who may be concerned with photogrammetry, either from the aspect of flying and photography or as engineers who wish to make use of it, rather than for those who wish to gather a detailed knowledge of the processes. As the authors remark in the preface, "Engineers especially find that a basic knowledge of the subject is essential for full understanding of the possibilities to which photography may be put. Especially is this true of Civil Engineers. . . . The Armed Forces have been quick to realise this as is evidenced by the inclusion of this subject as part of the basic training for members of the air forces."

In view of its purpose the book is mainly descriptive in character and is profusely illustrated. It is very readable and should be easily understood by those who wish to acquire the outlines of the subject. The treatment is from the American aspect, British practice not being mentioned, although a number of European instruments are referred to. The inclusion of more than a passing reference to multi-lens photography and its rectification is somewhat surprising, because the almost universal use of wide-angle single-camera photography has superseded it except for the assembly of three cameras—generally known as Tri-Metrogon—for reconnaissance mapping. With these reservations, the book can be thoroughly recommended to those who wish to gain a general idea of the subject. C. A. H.

Das Pflanzenkleid der Mittelmeerländer

Von Prof. Dr. M. Rikli. Three vols. Pp. 1418+200 plates. (Bern: Hans Huber, 1943, 1946 and 1948.) 122.50 Swiss francs.

VOL. 3 completes Prof. Rikli's authoritative and unique work on the Mediterranean countries, a work which, in addition to assembling a vast amount of botanical information on the region, depicts the effect upon the plant cover not only of climate, but also of the various civilizations, old and new, which have made their mark upon the Mediterranean.

The first two volumes have already been reviewed in *Nature*, **152**, 117 (1943); **153**, 445 (1944); and **160**, 416 (1947). The third and final volume supplies an author index and a very full genera and subject index combined. The greater part of the volume, however, is occupied by a list of the pertinent literature, which comprises 3,700 titles classified according to subject, the entries under regional plant geography—a very large section—again being subdivided geographically. Further, there is a list of the author's extensive travels in the region over a period covering 1889 to 1936, lists of the plates, figures in the text and maps of plant distribution, and an index of the countries, places and civilizations treated.

G. M. ROSEVEARE

PHYSICS AND CHEMISTRY OF HYDROCARBON GELS

ON March 24, a Royal Society Discussion was held on the subject of the physics and chemistry of hydrocarbon gels. Interest in these systems arose in the first instance from the desire to extend the range of flame throwers in which hitherto ordinary liquid hydrocarbons had been used. It was evident at a very early stage in the investigation that a possible improvement in range could be effected if the fuel could be made thixotropic in character, or at any rate if its intrinsic viscosity could be varied over wide ranges on changing the rate of shear. Further investigation revealed the fact that another physical property or combination of properties embraced under the term 'stringiness' or 'extensibility' had also to be taken into consideration.

Since gels are two-phase systems, inquiry centred around the preparation of suitable hydrocarbon gels. The gel-forming polymeric network could be introduced into the hydrocarbon by swelling and dispersion, or could be formed *in situ* as a result of suitable chemical reaction. Of the former, the early rubber–petrol systems were soon replaced by *iso*-butylmethacrylate or by cellulose acetate in a suitable fuel solvent, whereas the aluminium soaps of fatty acids were found to be most suitable among the latter class.

A linear polymer will dissolve in a hydrocarbon if the free energy of solution ΔF is negative. A high heat of solution ΔH may counterbalance the large (for polymers) entropy ΔS of solution. If $\Delta F = \Delta H - T\,\Delta S$ is positive, complete solution does not occur, but there results a swollen gel in equilibrium with almost pure solvent.

The degree of swelling of the gel phase is determined by a solvent-polymer interaction term μ. For linear polymers, μ can be defined by

$$\Delta F = RT \log (1 - v) + v\left(1 - \frac{1}{n}\right) + \mu v^2,$$

where v is the volume fraction of the polymer and n the ratio of solute/solvent molecular weight.

For a cross-linked polymer, the free-energy term must include not only the change due to dilution, but also the elastically stored free energy in the swollen network; expressions for this term, both for equilibrium strain-free and strained conditions, were described by Dr. L. R. G. Treloar.

This elastic energy may be stored as orientation entropy in the flexible chains, as potential energy in bent or stretched valency bonds or as a twist against the hindered potential opposing free rotation about the C—C axis. In the case of an isolated long-chain molecule, Kuhn showed that the force per unit extension would be inversely proportional to the number of bonds for orientation entropy and inversely proportional to the square of the number for twisting against hindered rotation.

The molecular spring in a gel is the average strand between two junction points in the framework, and the number of junction points as well as the number of strands is evidently proportional to the square of the volume concentration. The average length of a strand is, conversely, proportional to the concentration; consequently, the rigidity of the network should be proportional to the square of the volume concentration for the energy stored in the chain entropy, and to the cube of the concentration for twisting against hindered rotation. Data on the rigidity of gels as a function of the concentration of gelling polymer are scanty; but, such as they are, they suggest that twisting of the chains against hindered rotation rather than bond extension or chain entropy is the main factor involved.

It is evident that to obtain a fuller understanding of this partition of polymer between swollen gel and dilute solutions as separate phases, a close examination of the phase behaviour of polymer and solvent is desirable. Dr. A. E. Alexander gave an account of the examination of the swelling and solubility of cellulose acetate in benzene–xylenol mixtures. He has found that the solubility of the acetate in benzene–xylenol mixtures is greatly influenced by the degree of acetylation. By comparing the solubilities and swelling powers of the separated fractions in benzene–xylenol mixtures of different compositions, it has been shown that preferential adsorption of the xylenol takes place from these mixtures, and from the two sets of experiments phase diagrams have been constructed which when superimposed on one another reproduce the data obtained with the original material.

The rather complex rheological properties of these 'thickened' hydrocarbon systems were the subject of several communications, including those of Dr. A. H. Nissan, Dr. K. Weissenberg and Mr. R. S. Rivlin.

While the majority of these polymer-containing hydrocarbon systems are thixotropic in character and thus can store potential or elastic energy when distorted, they all exhibit the property of anomalous viscosity or non-Newtonian flow; indeed, the intrinsic viscosity may vary as much as a millionfold when the rate of shear is changed.

The point of thixotropic breakdown is now generally associated with a balance being achieved between the rate of cross-linking or bond formation and bond breaking, and it is evident that if these can be regarded as independent rate processes, the anomaly in the viscosity shear curves can readily be interpreted. Attempts have also been made to apply the considerations advanced by Eyring to these systems; but the physical interpretation of the actual mechanics of the processes involved on this basis is by no means clear. One of the most interesting conclusions arrived at from theoretical argument is the fact that to describe the flow properties of these solutions, two, and not one, physical parameters are required. If viscosity be chosen as one of them, the other is a normal stress coefficient. In a steady state of flow the normal stress coefficient may not vanish and will give rise to many of the effects which these anomalous liquids exhibit.

A great deal of attention has been devoted to the aluminium soaps as gelling agents for hydrocarbon fuels, and communications on this subject were made by Dr. A. E. Alexander, Dr. G. A. Parry and Dr. J. H. Schulman. Aluminium exhibits six-fold coordination and is amphoteric in its salts. The simplest compounds may be regarded as derivatives of $[Al(OH)_6'''] \overset{+}{H}_3$ (aluminic acid) and $[(H_2O)_6 \rightarrow \overset{+++}{Al}]\,Cl_3$ respectively. Salts of the type $[(H_2O)_6\ Al\ \overset{++}{R}]\ \bar{R}_2$ can evidently be prepared.

Bjerrum and Stiasny were the first to examine the condensation of these substances by the elimination

of water by processes they termed 'olation' and 'oxolation', and condensation polymers up to the tetramer can readily be identified.

For the purposes of gelation, the anhydrous aluminium soaps are most readily prepared by reaction of the aluminium alkoxides formed by direct interaction of the metal with the alcohol and fatty acids in an organic solvent, although similar results can be obtained from freshly precipitated aluminium hydroxide and the free fatty acids, or by ordinary metathesis between an alkali metal soap and an aluminium salt.

There still appears to be a certain amount of doubt in respect to the nature of the soaps of aluminium. The existence of di-acid soaps, $Al(OH)L_2$ and $Al(OR)L_2$, where L is the acid radical, is well established both by Karl Fischer's method for water determination and also calorimetrically from the heats of neutralization. Neither the tri- nor mono-soap appears to be readily prepared, at least from aqueous solutions, the product consisting mainly of the di-soap with adsorbed free fatty acid or hydrated alumina.

The complexes formed in strong solutions can be broken down by means of peptizing agents. Their mode of action can be ascribed to the breaking of the aluminium oxygen co-ordinate links by preferential co-ordination with the peptizer, and thus a large variety of compounds, such as water, amines, pyridine, alcohols, and, after that, phenols and fatty acids, can serve as peptizers.

ERIC K. RIDEAL

VARIABLE AND CONSTANT COMPONENTS OF CHROMOSOMES

By DR. A. E. MIRSKY and HANS RIS
Rockefeller Institute for Medical Research, New York

A STUDY of isolated chromosomes has shown that they contain desoxyribonucleic acid, histone and another protein of an entirely different character from a histone[1]. This protein remains as a microscopic fibre after extraction of desoxyribonucleic acid and histone from the chromosome. The coiled thread that is left after removing desoxyribonucleic acid and histone is called a 'residual chromosome', and the protein of the thread is referred to as the 'residual protein' of the chromosome. Some ribonucleic acid is combined with residual protein. The thread of residual protein is the basis for the thread-like structure of the chromosome. In the isolated chromosomes that were first prepared, those of nucleated erythrocytes of the carp and of calf thymus, the residual protein represented only 4 and 8·5 per cent respectively of the dried mass of the total chromosome, the remainder of the lipid-extracted chromosome being almost entirely nucleohistone.

Isolated chromosomes have now been prepared from beef liver, kidney and pancreas. For this purpose it was necessary to add several steps to the original procedure, for otherwise the chromosomes obtained were contaminated with considerable quantities of non-chromosomal material. In a suspension of isolated chromosomes, morphologically different individuals can be identified, and the same chromosomes are found in preparations from thymus, liver, kidney and pancreas of the same organism. This recognition of chromosome individuality in preparations of isolated chromosomes from different tissues is especially striking when the chromosome is the one to which a nucleolus is attached.

Fractionation of liver, kidney and pancreas chromosomes shows (figures given in Table 1) that their composition differs markedly from that of erythrocyte and thymus chromosomes, in that the former contain less nucleic acid and far more residual protein.

The composition of a chromosome appears to be related to the nucleo-cytoplasmic ratio of the cell in which it is located. Thymus lymphocytes have only a scanty cytoplasm compared with the abundant cytoplasm present in most cells of the liver, kidney and pancreas. We find that the nucleus represents 60 per cent of the mass of thymus cells and only 10–18 per cent of the mass of cells of the liver, kidney and pancreas. Chromosomes of nucleated erythrocytes, as seen in Table 1, have a composition that would be expected if they were in a cell with scanty cytoplasm. They have, in fact, a large cytoplasm, but one that is relatively inert metabolically. This shows that what is significant in the relationship between nucleo-cytoplasmic ratio and chromosome composition is the metabolic activity of the cytoplasm, as well as its bulk. Further evidence may be cited relating chromosome composition to nucleo-cytoplasmic ratio of the cell. The lymphocytes in the lymph nodes of beef contain far more cytoplasm than do the lymphocytes of calf thymus; and, in accordance with the rule that has just been mentioned, the nuclear substance of lymph node lymphocytes has a much lower percentage of desoxyribonucleic acid. The nucleo-cytoplasmic ratio of liver cells changes considerably when an animal fasts. In fasting, there is a decrease in the ratio of cytoplasm to nucleus. In these circumstances we would expect to find the percentage of desoxyribonucleic acid in the nuclear substance of liver cells to increase during fasting—and analysis does, indeed, show this.

Table 1

Chromosomes of:	Desoxyribonucleic acid (per cent)	Residual protein (per cent)
Carp erythrocyte	41	4
Calf thymus	39	8·5
Calf liver	26	39
Calf kidney	28	33
Beef pancreas	28	29

From the data given in Table 1 it cannot be said whether the differences in percentage composition of chromosomes of different cells of the same organism are due to variations in the quantity of nucleic acid or in the quantity of residual protein present in a given chromosome. When cytologists observe differences in staining of chromosomes, they frequently conclude that more or less chromatin is present in the chromosomes. The material in the chromosome that stains (chromatin) is desoxyribonucleic acid, and in the cytological literature there are many statements, based on staining, concerning an alleged increase or decrease in quantity of desoxyribonucleic acid in chromosomes. What is actually being observed is a change in percentage composition. An apparent decrease in quantity of nucleic acid (chromatin) may be simply a decrease in the percentage of nucleic acid due to an increase in quantity of residual protein in the chromosome, the actual quantity of nucleic acid in the chromosome possibly remaining constant.

The quantity of nucleic acid in a single nucleus can be determined if the number of nuclei can be counted in a given mass of material used for analysis. For some cells, those of liver, for example, this is readily accomplished by isolating a mass of nuclei using the citric acid method and counting the number in a given volume of the suspension. In other cases, erythrocytes and sperm, the cells themselves can be counted. A comparison of the desoxyribonucleic acid contents of the nuclei of the erythrocyte and liver cell of the domestic fowl is of interest. Analysis of dried liver nuclei shows that 21·8 per cent is desoxyribonucleic acid, whereas of the dried erythrocyte nuclei 40·4 per cent is desoxyribonucleic acid. Despite this difference, the *quantities* of desoxyribonucleic acid per nucleus are found to be identical for these two nuclei. The analytical figures for the fowl, a number of fish, the frog, toad and turtle are given in Table 2. The quantity of desoxyribonucleic acid is a constant for different cells of the same animal, and the value of this constant is a characteristic of each species.

Table 2

Animal	Desoxyribonucleic acid (mgm. × 10^{-9}) in: Nucleus of erythrocyte	Nucleus of hepatic cells	Sperm	Number in previous column × 2
Domestic fowl	2·34	2·39	1·26	2·52
Shad	1·97	2·01	0·91	1·82
Carp	3·49	3·33	1·64	3·3
Brown trout	5·79		2·67	5·34
Frog	15·0	15·7		
Toad	7·33		3·70	7·40
Green turtle	5·27	5·12		

Different as erythrocytes and liver cells are from each other, one point of identity is that they have the same number of chromosomes, and it is surely significant that desoxyribonucleic acid is found in the chromosomes only. Because of these considerations, and because sperm cells have one half the number of chromosomes found in somatic cells, the quantities of desoxyribonucleic acid per sperm cell were determined for various species. From the results given in Table 2, it can be seen that the quantity per sperm cell is one half that found in a somatic cell. Observations on egg nuclei show that the quantity of desoxyribonucleic acid in the egg nucleus corresponds very closely to that in the sperm. If the data given in Table 2 are considered in relation to the chromosome theory of heredity, the conclusion that follows is that desoxyribonucleic acid is part of the genic material. This does not mean, however, that the gene consists of nothing but nucleic acid.

Since the quantity of desoxyribonucleic acid per nucleus is a constant for a species, it has been determined by us for a considerable number of animals, invertebrates and vertebrates. These values are of interest from an evolutionary point of view.

Once it is known that the quantity of desoxyribonucleic acid per nucleus is the same in different cells of an organism, it becomes clear that the quantity of residual protein varies considerably. A cell with an abundant, metabolically active cytoplasm has chromosomes with a large quantity of residual protein; and a cell with scanty cytoplasm has chromosomes with but little residual protein. The residual protein of the chromosome, it would seem, is concerned with interactions between chromosome and cytoplasm. Since the needs of the cytoplasm vary in different cells, and vary in a given cell at different times, it is scarcely surprising that the residual protein is, at least in part, a variable component of the chromosome.

Table 3

Nucleus of:	Desoxyribonucleic acid in 1 nucleus × 10^{-9}	Multiple of value found in sperm
Bull sperm	2·82	
Calf thymus	7·15	2·54
Calf lymph node	7·03	2·49
Calf kidney	6·25	2·21
Beef kidney	6·81	2·41
Calf liver	6·22	2·20
Beef liver	8·4	3·0

In Table 2 no values for mammals are given. Table 3 contains some analytical values for the nuclei of cattle. It will be seen that there are some variations from the simple relationships found in other vertebrates. It is well known that polyploidy occurs in mammalian liver, but polyploidy is not the explanation of the high value found for beef liver, for in counting liver nuclei the double-size nuclei were counted separately and the necessary correction was made. It is probable that some other duplication of genic material is responsible for the analytical results given in Table 3.

Finally, it should be mentioned that Boivin[2] and his collaborators have made determinations of the quantity of desoxyribonucleic acid per nucleus in several mammals. Their work and ours have been done altogether independently of each other. A comparison of the analytical values shows that some of their results differ from ours.

[1] Mirsky, A. E., and Ris, H., *J. Gen. Physiol.*, **31**, 1, 7 (1947).
[2] Boivin, A., Vendrely, R., and Vendrely, C., *C.R. Acad. Sci., Paris*, **226**, 106 (1948). Vendrely, R., and Vendrely, C., *Experientia*, **4**, 434 (1948).

MODE OF PRODUCTION OF CHROMOSOME ABNORMALITIES BY THE NITROGEN MUSTARDS

THE POSSIBLE ROLE OF CROSS-LINKING

By R. J. GOLDACRE, A. LOVELESS
AND
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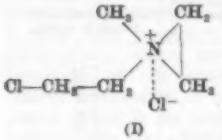
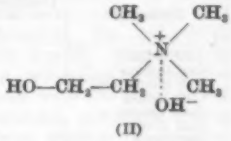
IN a recent publication[1] attention was directed to the cytotoxic action of a series of halogenoalkylarylamines, of which the compound $PhN(CH_2CH_2Cl)_2$ may be taken as typical. The structural conditions requisite for activity were stated to be the presence of two halogenoalkyl groups in the molecule together with a certain minimum reactivity of the halogen, as measured by the ease of hydrolysis. In the cytological changes which these compounds produce they largely resemble their aliphatic analogues.

The action of the nitrogen mustards has been connected with their ability to pass into a cyclic ethyleneimonium ion (I)[2]. This ion presents a formal resemblance to choline (II), as pointed out by Barron, Bartlett and Miller[3], and these authors have found that the aliphatic nitrogen mustards are antagonists

for choline oxidase, acetylcholine-esterase and choline-acetylase :



(I)



(II)

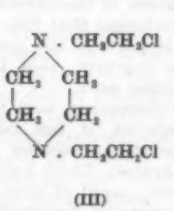
While formation of a cyclic ion may also occur in otherwise inactive compounds with only one halogenoalkyl side-chain, the presence of a second side-chain obviously permits a much closer analogy with choline, and might conceivably be significant in this way. In a recent paper[4] it is, however, shown that there is no evidence for the formation of a cyclic ion from the aromatic nitrogen mustards, while the possibility of the transitory existence of such an ion cannot, of course, be completely excluded. The evidence against the existence of a cyclic ion is, briefly, as follows : (1) the amount of halide ion liberated is at all times equal to the acidity produced, and it can be assumed that no quaternization of the nitrogen atom occurs ; (2) the instantaneous reaction with thiosulphate, which has been used as a measure of the concentration of the cyclic ion, is not observed with these compounds ; (3) although S. D. Ross has shown[5] that 1-diethylamino-2-chloropropane undergoes a rearrangement on hydrolysis which is interpreted as involving the closing of the ethyleneimonium ion followed by re-opening of the ring at a different point, the analogous aromatic compounds have not been found to undergo such a change.

It has already been suggested that the cytotoxic activity of the nitrogen mustards may be due to the alkylating effect of the halogenoalkyl group on functional groups of body constituents. Thus the active aliphatic compounds react with amino, sulphydryl, carboxyl and imidazole groups in proteins[6] and almost certainly with amino and secondary phosphoryl groups in nucleic acids, as has been found for di(chloroethyl) sulphide, one molecule of which may react with two groups[7]. Now there is considerable evidence[8,9,10] that groups such as these in the protein molecule are not always accessible, but are at some time buried within the molecule, owing to a change in the folding of the polypeptide chain, which is held by Astbury[11] and Seifriz[12] to be the basis of protoplasmic contractility in general. In particular, it is suggested that the shortening of prophase chromosomes is a continuation of the shortening by molecular folding of the chromosome's constituent fibres, which must at some stage in the resting nucleus be completely unfolded to ensure that all parts of the template contribute to re-duplication.

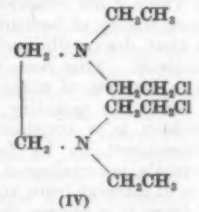
Apart from the possible implication contained in the paper by Barron *et al.*[3], no explanation has so far been given of the necessity for two halogenoalkyl groups in a single molecule. A fresh possibility is now suggested, namely, that the two groups are required to permit the molecule to react at two distinct points, lying either on a single surface or fibre or, more especially, on two contiguous fibres. Thus, when the first haloalkylamino group has become anchored to a reactive centre, the second group approaches and can react with another centre either on the same protein chain or on an adjacent one. The possibility that cross-linking may play a part in the action of mustard gas on the nucleic acids has already been considered by Elmore *et al.*[7], in an investigation which these authors believed might provide an explanation of the cytological effects of mustard gas as described by Koller[13], Robson[14] and Fell and Allsopp[15].

Of the various possibilities, cross-linkage between separate fibres is of particular interest when considered in the light of the assumption that reaction is directly with the genetic material. The latter has already been postulated in respect of chemical mutagenesis[16], while it is known that the cell is most susceptible to the effects of the mustards immediately prior to mitosis when the chromosome has just re-duplicated[17]. There is therefore at this time a system in the cell consisting of parallel identical fibres, the gene strings of the sister chromatids. Moreover, the fibres are extended in the process of re-duplication and could be, by analogy with stretched elastic polymers, at their highest energy : it is not difficult to visualize breakage of chromatids or of whole chromosomes as the direct consequence of interchromatid cross-linkage at this time (for example, fragmentation could result from tension upon the extended threads of the interphase chromosomes cross-linked so as to produce a junction stronger than the fibres themselves). Furthermore, the possible uniqueness of such a system in the cell would account for the high degree of specificity of action shown by compounds of this type. The cytological changes due to the mustards are remarkably similar to those observed after treatment by X-radiation[18], and in the latter case equally it would appear worthy of investigation whether the effects are due to cross-linkage between adjacent protein chains. Such a union could arise, for example, by the interaction of two —SH groups under the oxidative influence of X-radiation which is known to occur *in vitro*.

Consideration of the above principles has suggested that many other molecular types, containing two or more groupings capable of similar reaction with functional centres in biological systems, would be effective as cytotoxic agents. Examples are already known of active compounds in which the two requisite haloethyl groups are attached to different nitrogen atoms (for example, III, IV), and it is obvious that a great number of variants, especially involving heterocyclic types and modification of the side-chains, calls for investigation : work along these lines is proceeding, as also upon the possible antagonistic action of thiols, and will be reported later.



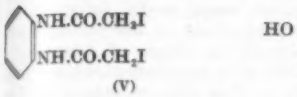
(III)



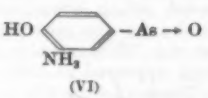
(IV)

One compound of this type upon which preliminary tests have been made is di(iodoacetyl)1 : 2-phenylenediamine (V). In tests on larvæ of *Triturus palmatus* typical radiation effects were produced in epithelial cells, fragment formation and anaphase bridges both with and without accompanying fragments being observed. The compound 'Mapharside', 3-amino-4-hydroxyphenylarsenoxide (VI), which can undergo a reversible condensation reaction with a pair of —SH groups[19], has also been tested in the same manner.

In this case the effect was to produce 'stickiness' after a few hours, and at periods of 24–48 hours after treatment, anaphase bridges with and without accompanying fragments: no fragmentation was observed except in association with bridges.



(V)



(VI)

The above suggestions as to the mechanism of action of the nitrogen mustards are put forward purely as a working hypothesis, and as possibly the simplest of a number of alternative explanations consistent with the chemical and cytological data. If, however, it is indeed true that chemical substances of these kinds produce some of their characteristic effects by reacting directly with the uncoiled resting chromosomes in the manner described, a new approach will become available to the related problems of growth inhibition, induced mutation and carcinogenesis. The connexion between these phenomena is now receiving further emphasis from the fact that tumour induction by the nitrogen mustards has recently been achieved both in the aliphatic series[10], and in the aromatic series[11]. Further reports upon this last subject will be published elsewhere.

The authors wish to express their indebtedness to Prof. A. Haddow for much advice and encouragement. The investigation upon which this discussion is based has been supported by grants made to the Chester Beatty Research Institute by the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the Division of Research Grants of the U.S. Public Health Service, and is being conducted during the tenure by one of the authors (W. C. J. R.) of a Sir Halley Stewart Fellowship, and by another (R. J. G.) of a grant from the Forsyth Bequest of the Royal Society.

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OBITUARIES

Sir Thomas Hill Easterfield, K.B.E.

SIR THOMAS HILL EASTERFIELD died at Nelson, New Zealand, on March 1, aged eighty-three, and on March 18 his ashes were scattered in a garden nook at the Cawthron Institute. He was born at Doncaster, Yorkshire, in 1866, received his primary education at the Doncaster Grammar School, and later entered the Yorkshire College (now University of Leeds), where he won a scholarship in geology and gained his first insight into chemical research, which inspired his life-work. From Leeds he proceeded to Cambridge as a foundation scholar of Clare College and gained first-class honours in the Natural Sciences Tripos; this was followed by studies at the Zurich Polytechnic School and at Würzburg. In 1888 he returned to Cambridge as a junior demonstrator in the University Chemical Laboratory, becoming a University extension lecturer in 1891, and in 1894 lecturer on pharmaceutical chemistry and chemistry of sanitary science; he was also a master at the Perse School.

In 1899 Easterfield was appointed one of the four foundation professors of the Victoria University College, Wellington, New Zealand. He held the dual chair of chemistry and physics until 1909, continuing as professor of chemistry until 1920, when he became the first director of the Cawthron Institute, Nelson, from which position he retired in 1933 after a full and active professional career. In 1938 he was honoured by knighthood in recognition of his outstanding services.

Apart from his scholastic attainments, Easterfield was a Cambridge 'miler' and took an active part in athletics. Further, as a churchman he was imbued with, and practised, the principles of Christianity which moulded his outlook and guided his footsteps. Such was this distinguished citizen who carried with him a strong sense of justice, a keenly developed flair for research, and the experienced technique of an able teacher, all of which traits left their mark on the many who had the good fortune to come under his influence.

Though Sir Thomas Easterfield will ever be remembered as an outstanding chemist who created from virtually nothing—much of the equipment was of his own making—the Department of Chemistry at Victoria College, Wellington, successfully fathering such an undertaking through all vicissitudes, it must be stressed that his scientific horizon was by no means limited by chemistry; he possessed a wide understanding of both physical and biological sciences. He held the unshakable belief that fundamental research is the prime factor in scientific advancement; he held an equally strong belief in the necessity for the application of science. It was this broad and tolerant outlook which so fitted him to direct, from their infancy, those physical and biological researches, both fundamental and technical, which, through his foresight and ability, caused the Cawthron Institute to develop so rapidly to a high standing among research organisations.

DAVID MILLER

Mr. G. M. Mathews

GREGORY MACALISTER MATHEWS, author of "Birds of Australia", died at Winchester after a short illness on March 27. He was the son of R. H. Mathews, a well-known authority on Australian aborigines, and

was born at Biamble, New South Wales, on September 10, 1876. After attending King's School, Parramatta, he worked on a cattle station in north Queensland and spent much of his spare time studying birds. He amassed a large collection, supplemented by many specimens received from correspondents all over Australia. For long he had planned to write a work on Australian birds, and in 1902 went to England for the purpose. At first he resided near Watford, which was convenient for the British Museum (Natural History) and Lord Rothschild's museum at Tring, where much of his work was done.

As a preliminary to his larger work, he published in the *Emu* during 1908 a "Handlist of the Birds of Australia"; then in 1912 the "Birds of Australia" began to appear, and this was finally completed in 1927 in twelve thick folio volumes. His next work was a check list of the birds of Australia and the Polynesian region, entitled "A Systema Avium Australasianarum", brought out under the auspices of the British Ornithologists' Union. Mathews had long been interested in two small islands lying between Australia and New Zealand, and in 1928 he published an account of the birds entitled "Birds of Norfolk and Lord Howe Islands", followed eight years later by a supplement.

In his earlier works he was an extreme 'splitter', and a large number of his races are not now recognized. In genera, too, he went to the same extreme, and this to a great extent was due to his confining his studies to Australian species only. In recent years, however, he greatly modified his views. He was greatly interested in nomenclature and the study of early writers on Australian birds, and his best work was done in this connexion. Between 1912 and 1927 he edited a magazine of his own, *Austral Avian Record*, which contained much useful information. But by far the most important of his publications was the "Bibliography of the Birds of Australia", which appeared in 1925 as a supplementary volume to "Birds of Australia". This is more than a bibliography, and might be considered the foundation for a history of the study of birds in Australia.

Mathews was a great collector of books and amassed the finest collection of works dealing with Australian birds. This he presented to the Australian Government in 1929, and it is now housed in the National Library in Canberra as the Mathews Ornithological Library. His collection of birds passed into the hands of the late Lord Rothschild and is now in the American Museum of Natural History in New York.

Mathews was a keen sportsman, interested in both hunting and shooting, and while engaged in his ornithological studies travelled widely, visiting most of the more important museums both in Europe and the United States. In 1924 he was vice-president of the British Ornithologists' Union and during 1936–38 was chairman of the British Ornithologists' Club. He married Marian, daughter of H. C. White, of Mudgee, New South Wales, who died in 1938, and is survived by a son.

N. B. K.

NEWS and VIEWS

Zoology at King's College, London: Dr. J. F. Danielli

Dr. Danielli, who is succeeding Prof. Mackinnon as professor of zoology in King's College, London, commenced research work in 1931 at University College under the direction of Prof. N. K. Adam. He was then working on monolayers of steroids and on cell permeability. In 1933 he went to Princeton University with a Commonwealth Foundation Fellowship and continued his work under the influence of Prof. E. N. Harvey and Prof. C. G. Conklin. He returned to University College, London, under the auspices of Sir Jack Drummond and Prof. A. V. Hill. From University College he went to Cambridge in 1938, with a Beit Memorial Medical Research Fellowship tenable in the Department of Biochemistry. Here his work was extended to the blood capillaries. He became a member of a Ministry of Supply extra-mural chemical defence research team and a fellow of St. John's College in 1942. During his later years in Cambridge he was attached to both the Departments of Zoology and Biochemistry, and his main attention was turned to cytochemistry. In 1946 he went to the laboratory of the Marine Biological Association as physiologist, and then became reader in cell physiology of the University of London at the Chester Beatty Research Institute of the Royal Cancer Hospital, and also honorary lecturer in pharmacology at University College. He plans to continue the programme developed at the Royal Cancer Hospital, and to develop research work in cytology particularly in collaboration with Prof. T. A. Bennet Clark and Prof. J. T. Randall.

Geography at Cambridge: Mr. J. A. Steers

Mr. J. A. Steers, who, in September, is to succeed Prof. F. Debenham as professor of geography in the University of Cambridge, was one of the first generation of geographers to take the newly constituted Geographical Tripos after the First World War. After a short spell of teaching at Framlingham, Mr. Steers returned to Cambridge to join the staff of the Geographical Department under Philip Lake. His College elected him to a fellowship, and before many years St. Catharine's became the first men's college to offer scholarships in geography. This led to a remarkable concentration of able geographical students in the College, which has resulted in a rapidly lengthening list of St. Catharine's geographers entering university posts—fifteen in the last ten years. In his College, Mr. Steers has served successively as dean, tutor, senior tutor, and president.

The Norfolk coast was the scene of Mr. Steers's early researches, and his frequent visits led to Norfolk replacing his own native Bedfordshire as his favourite county. These activities centred mainly on Scolt Head Island, where for many years parties of Cambridge men mixed the more sober academic pursuits with strenuous bursts of bathing and creek jumping. His taste for coastal problems led him to other parts of Britain, and culminated in two expeditions to the Great Barrier Reefs of Queensland, and one to Jamaica. A succession of papers followed promptly on various aspects of the physiography of coral reefs —the main work of writing up was sometimes accomplished on board the ship while returning to England. During the Second World War his love of the coastline led him to turn his attention to the

preservation of its amenities, and his major publication, "The Coastline of England and Wales", was intended to serve the double purpose of summarizing the state of our knowledge of the coastline and of focusing attention on the need for preserving this ample but easily marred heritage. He has completed a report on the English and Welsh coasts for the Minister of Town and Country Planning, and is now engaged on a similar project for the Scottish Office. Mr. Steers's interests have by no means been confined to the coastline. His first book, "Map Projections", was a surprising and most adequate production for one who lays no claim to mathematical knowledge. "The Unstable Earth" is more representative of his real interests, which have always been close to geology; but perhaps "Scolt Head Island" expresses most nearly his approach to problems, in that it brings together the work of specialists on the various field studies in the elucidation of one specific region.

Hosiery Research Council: Dr. D. Starkie

DR. DAVID STARKIE has been appointed director of research by the Hosiery Research Council. The appointment is one of the most important preliminary steps yet taken in the establishment of a research organisation for the hosiery industry. Dr. Starkie, who is forty-four, was educated at Staveley Grammar School and the University of Sheffield, and obtained a degree in physics, with first-class honours, in 1925. He was awarded his M.Sc. in 1926 and Ph.D. in 1927 as a result of work on the band spectra of the alkali compounds. After leaving the University, Dr. Starkie lectured and carried out research on the physical properties of glass. He spent two years on research with the Metropolitan-Vickers Electrical Co., Ltd., and then became chief physicist at Messrs. A. Jobling and Co., Ltd., glass manufacturers. In 1939 Dr. Starkie was appointed head of the physics research department of the Plastics Section of Imperial Chemical Industries. Much of his time was devoted to the investigation of the properties of synthetic yarns and fibres, and he worked in close collaboration with a special fibres development department formed to develop the use of synthetic fibres in the textile industry. When it was decided to create an optical development department in 1944, Dr. Starkie was placed in charge of its formation, and the results of his work have had important effects in the optical field. Dr. Starkie is a member of a number of scientific societies and service committees and is also on the Council of the British Scientific Instrument Research Association. He will be responsible for the plan and organisation of the new Hosiery and Allied Trades Research Association now being formed. The Hosiery Research Council, which has done the preliminary work, already possesses premises equipped for research at Thorneywood House, Nottingham, where there is the nucleus of a trained staff.

Rumford Medals: Dr. I. S. Bowen

THE Rumford Medals for 1949 of the American Academy of Arts and Sciences, given for the most important discoveries in the fields of heat and light, have been awarded to Ira S. Bowen, director of the Mount Wilson and Palomar Observatories in California. It was Bowen's early laboratory study of high-excitation spectra which laid the foundations for his brilliant work on the identification of the 'nebulium' lines in the spectra of galactic nebulæ as forbidden transitions in doubly ionized oxygen. Later, his analysis of the spectra of planetary nebulæ brought to light the unexpectedly high cosmic abundance of the inert gases. The puzzle of the selective excitation of certain permitted lines in nebular spectra was explained by him in a completely satisfactory way in terms of close chance coincidences between the wave-lengths of emission lines in the inaccessible ultra-violet. Dr. Bowen is well known also as an optical designer. Perhaps the most useful device associated with his name is the 'image slicer', by which the starlight that would otherwise be wasted on the slit-jaws of an astronomical spectrograph is directed into the instrument, thus greatly increasing its effective speed. He is now in charge of the installation of the new 200-in. reflector at Mount Palomar, and is credited with a number of devices used in the optical tests. His many friends look forward with confidence to the successful initiation of the new telescope under his direction.

The Palæobotanical Society and Institute of Palæobotany, Lucknow

ON April 3, the Hon. Pandit Nehru, Prime Minister of India and Minister for Scientific Research, laid the foundation stone of the newly formed Institute of Palæobotany in Lucknow. This Institute has come about as the result of a resolution passed on September 10, 1946, by the governing body of the Palæobotanical Society which had just previously been founded. The president of the Society is Mrs. Savitri (Birbal) Sahni, and the secretary, Prof. Birbal Sahni, professor of botany in the University of Lucknow.

Both Society and Institute have clearly come into being as a result of the enthusiasm of Prof. Sahni, who himself is one of the world's leading palæobotanists, and the keen interest of his wife. On the schedule of the Palæobotanical Society are Prof. Sahni's collections of scientific literature and fossil specimens; funds up to Rs. 100,000 given by Prof. and Mrs. Sahni for the building of the Institute; a perpetual endowment of Rs. 1,000 in 3½ per cent Government paper, presented by Pandit L. D. Pant for the Chandra Datt Pant Commemoration; two scholarships, furniture and laboratory equipment given by the Burmah Oil Company. It is also interesting to note that after the death of Prof. and Mrs. Sahni, all their assets are to go to the Society and Institute. Pending the completion of its own building, the work of the new Institute of Palæobotany is being carried out in a building (given to the Society by the Government of the United Provinces) by the director (Prof. B. Sahni), assistant director (S. R. Narayan Rao), curator (J. Hsü), research fellow (R. V. Sitholey), research assistants (R. N. Lakhanpol and D. C. Bhardwaj) and registrar (B. R. Agarwala). K. R. Surange has also recently joined the staff.

Commonwealth Scientific and Industrial Research Organisation, Australia

THE Australian Government in March repealed the Science and Industry Research Act of the Bruce-Page Government of 1926, replacing it and its subsequent minor amendments by a single Act modifying several of the main features of the original legislation. From the Council for Scientific and Industrial Research, which has functioned for twenty-three years, all former powers and functions have been taken away, and it becomes for the future merely advisory. A new body has been set up under the title Commonwealth Scientific and Industrial Re-

search Organisation. It consists of an Executive of five members and of the officers comprising the staff. The Executive is the governing body. Its members will be appointed by the Governor-General, and at least three of them are to possess scientific qualifications. The chairman and two others will devote the whole of their time to the duties of office. Whereas the former Council carried sole responsibility for the scientific programme placed before the Government, provision is now made for political initiation of work, it being the duty of the Organisation to exercise its powers and functions in relation to any matter referred to it by its minister. In the important matter of staff, while the Executive may appoint such officers and employ such temporary or casual employees as it thinks necessary for the purposes of the Act, it is in each case subject to the specific direction that "the selection of persons . . . shall be made in accordance with such requirements as the Public Service Board determines". So, too, terms and conditions are in all cases "subject to the approval of the Public Service Board". Also, the maximum number of officers and employees whose duties are primarily of an administrative or clerical nature is similarly subject to the Board's approval. Under the earlier Act, the Council and minister settled these matters, independently of the Public Service Board. A somewhat cryptic clause towards the end of the Act runs: "A member of the Executive, a member of the Advisory Council, a member of a State Committee, an officer or an employee shall not, except in the course of his duty as such a member, officer or employee or with the approval of the Executive, disclose any information concerning the work of the Organisation or the contents of any document in the possession of the Organisation. Penalty: Imprisonment for two years." The opportunity has been taken also to effect certain minor changes which experience has shown to be desirable; but it is difficult at this stage to predict just how the new legislation as a whole will affect established scientific activities. The sequel need not be unsatisfactory; but it is known that in some quarters the position is regarded with a measure of anxiety.

Progress in Education

In his presidential address to the National Union of Teachers at Margate on April 16, Mr. I. Gwynne Rees, of Port Talbot, outlined the extent to which the 1944 Education Act has already been implemented. Two years ago, at a time of unprecedented difficulties, school life for every pupil in Britain was extended to the age of fifteen. The number of teachers in primary and secondary schools is now 10 per cent greater than before the War, while the average number of pupils per teacher in the primary and secondary schools has been reduced by about 6 per cent; in the primary school, however, the average class still remains nearly 50 per cent larger than in the secondary school. These reforms, said Mr. Rees, have been made possible by the rapid increase in the supply of well-qualified teachers, provision having already been made for the training of 66 per cent more students in the permanent colleges and 44 per cent more in the universities than before the War. The other major reform necessary for the reduction in the size of classes is, he said, the provision of sufficient classrooms. In 1948 work in progress involved an ultimate capital expenditure of £23,000,000, and in 1949 the figure would be £55,000,000. There has also been remarkable progress in the facilities for higher education. The toll-gate of school fees has been removed, and State scholarships and local education authority awards for further education have doubled in number since 1939. In the earlier stages of education, particular concern is being felt for the infant and junior schools, where the handicapping of the less gifted begins through lack of suitable equipment and through classes of forty, fifty and even sixty children. This seventy-fourth Conference of the National Union of Teachers was distinguished, for the first time, by the presence of the Prime Minister. In an inspiring address, Mr. Attlee declared that the prime duty of all teachers is to train their pupils to become good citizens of a democratic society.

ISI Bulletin

A new quarterly journal, *ISI Bulletin*, has been issued by the Indian Standards Institution, *P* Block, Raisina Road, New Delhi. The price is 2*s*., and the first number contains thirty-six pages. The Indian Standards Institution was founded in 1947, primarily as an industrial organisation, but with Government support. The president is Dr. S. P. Mookerjee, Minister for Industry and Supply, and its director, Dr. Lal C. Verman. It has set up four executive committees for agricultural products, documentation, quality control and industrial statistics, and weights and measures, together with engineering, textile and chemical division councils, sponsoring a total of 118 committees and sub-committees. Draft standards on textile shrinkage tests and fireclay refractories have already been published. Apart from much detailed information the *Bulletin* contains the president's address to the general council and three very interesting general articles. The first of these, on the "Standard Atmosphere for Testing", compares average atmospheric conditions in India with those in other parts of the world and makes recommendations, which the Indian delegation was successful in getting accepted by the International Standards Organisation, for alternative 'standard atmospheres' to be adopted for use in industrial testing laboratories in tropical and temperate climates respectively. The second paper, on "Quality Control", is mainly a record of various conferences and papers relating to this subject, largely directed to its applications to the textile industry. The last paper deals with "Weights and Measures". It includes a brief summary of the past and present position in India, and puts forward a proposal for the adoption of the metric system with Indian names for the units, and a series of Indian prefixes and affixes to denote the successive powers (multiples and sub-multiples respectively) of 10. The *Bulletin* gives an impression of vitality which augurs well for the future success of the new organisation.

Scientific Information in India

Commenting on the Royal Society's Conference on Scientific Information Services in London last year (see *Nature*, August 21, 1948, p. 279), the *Journal of Scientific and Industrial Research* (*India*) (Nos. 9 and 10, pp. 387, 435; 1948) emphasizes the importance of such aids to research and the urgency of evolving a satisfactory system in India. It accepts the view that the primary requirement is a central organisation, maintaining liaison with similar organisations in other countries and directed by a man of science with width rather than depth of

interests, who is able to perceive and satisfy the bibliographical needs of a large clientele. The needs of a really adequate information centre, for assembling scientific and technical information from India and elsewhere and for distributing such information, require consideration both from the point of view of organisation and material. The research aspect of information and intelligence work does not appear to have been recognized sufficiently in India; and the editor calls for a lead from the Indian Department of Scientific and Industrial Research towards the organisation of an efficient service on lines emphasized at the Royal Society Conference and already adopted not only by the Department of Scientific and Industrial Research in London but also in Australia, New Zealand and Canada, and by the National Research Council of the United States.

German Wool Industry

THE Wool Industries Research Association has recently prepared "B.I.O.S. Overall Report No. 9: The German Wool Industry during the period 1939–1945" (pp. 56. London: H.M. Stationery Office, 1948. 1s. net). The report suggests that in respect of blending, carding, spinning, weaving, dyeing, finishing, shoddy and mungo manufacture, machinery design, operation and production there is little that the British industry can learn from its German counterpart. Much of the latter's woollen yarn industry was judged to be obsolete by American standards with, on the whole, low productivity, and, though allowance must be made for the quality of the raw material in use, the quality of work now being done was said to be poor by most of the investigators. Output was generally higher than with average Yorkshire setts; but the standard of carding was lower. The modified Duhamel scouring process is economical in both alkali and soap, and merits careful examination. Much attention has been devoted by the Germans to by-product recovery, although there is nothing new in principle in the processes used. The exact efficiency of the German worsted industry is difficult to assess; but it would appear that while, compared with Britain, the German industry has the advantage of better buildings, facilities and general amenities, German technicians have made no great mechanical or processing advances. Little advance in research was recorded in the war years, although some work on improving the sensitivity of wool to alkali, increasing the fastness of dyes, on moth-proofing, on low-temperature dyeing and the dyeing behaviour of the Palatine Fast dyes is noted. A bibliography of the reports and documents on which the report is based is appended.

Management Training at Staff College

IN the paper "The Staff College in Training for Management", Mr. N. F. Hall, principal of the Administrative Staff College, reviews his experimental work during the last two years in bringing the College into operation, and this paper has now been issued by the British Institute of Management, together with the introductory remarks of Sir Charles Renold and a report of the discussion, as the first report in the *Winter Proceedings* series of the Institute. Mr. Hall stresses that the task is to make a co-ordinated group out of individual specialists and to increase the capacity of those trained in administration and in different fields of technology to work together. The bulk of the work of each course is carried out by the discussion method, and this ensures that the basic principles of administration and their practical application will be examined. The study of biography has been introduced to provide opportunities for discussing the importance of personality and character in administration and to liberalize a concentrated practical course. While emphasizing the value of a well-balanced admixture of practical experience among the members of each session, Mr. Hall recognizes that the size of any mixed staff college must be small, both because of the importance of all members getting to know each other and because of the limits dictated by the group-discussion method used. Accordingly, great care should be exercised to avoid building up a privileged caste of those who have passed through the Staff College, from which there cannot at present be an annual output of more than about two hundred. As to the length of the course, Mr. Hall thinks it should remain at about three months or else be increased to a year; and for the present he thinks that three months represents a reasonable working compromise.

Fouad I University, Cairo: Faculty of Science

THE annual report, 1946–47, of the faculty of science, Fouad I University of Cairo, gives a brief description of the research activities, including particulars of papers published and some notes on researches in progress. In the Department of Pure Mathematics work is continuing on the distribution of cranial curves and on mortality tables, while in that of Applied Mathematics work is in progress on the unified field theory, the velocity potential of the fluid motion induced by the motion of a cylinder in an infinite mass of compressible fluid, and the effect of polarization on secondary scattered light. In the Department of Physics the subjects under investigation include electron polarization, viscosity of gases, electron diffraction by liquid films, the measurement of atmospheric turbulence, supersonic diffraction through slits and the viscosity of plastics. In the Department of Zoology the study of some biological and morphological aspects of lamellibranchs, the fauna of Egypt, the excretion of reptiles, and the embryology of scorpions is continuing, and a study has commenced of the anatomy, histology and physiology of the digestive system of some Egyptian Lacertilia. In the Department of Entomology work continued on some of the Bombyliidæ of Egypt, and on the biology and ecology of various dung insects.

The Country Journal

THE second number of the recently launched *The Country Journal* contains a collection of articles which should satisfy the varied tastes of those who live and work in the countryside and the unfortunate town-dwellers who wish to do so. There are articles for the farmer, the gardener, the botanist, the ornithologist, the bee-keeper and the member of the women's institute; while in an admirable survey many of the recent books on natural history and rural subjects are classified for the convenience of several types of readers. In the present number of the journal two articles of absorbing interest are those by Frank Illingworth on the countryman's games and Trevor Holloway on curious country place-names. Particulars of the new journal may be obtained from the Worcester Press, Worcester.

Virus Diseases of Lettuce

DANDELION yellow mosaic virus was first reported by B. Kassanis in 1944. He then showed that the disease could also affect lettuce. More recently (*Ann. App. Biol.*, **34**, No. 3, 412–421; Sept. 1947) the same author has described the symptoms and transmission of dandelion yellow mosaic and of lettuce mosaic. He also reports the isolation of cucumber mosaic from naturally infected lettuce. Lettuce is more susceptible to dandelion yellow mosaic than is its name host. The aphid *Myzus persicæ* transmits lettuce mosaic, but not dandelion yellow mosaic, which is, however, spread by *Myzus ornatus*, *M. ascalonicus* and *Aulacorthum solani*. The common lettuce aphid, *Nasonovia ribicola*, rather perversely transmitted neither virus. Lettuce mosaic is found in most samples of commercial seed; but dandelion yellow mosaic is not seed-borne.

Frank B. Jewett Fellowships: New Awards

THE American Telephone and Telegraph Co. has awarded the Frank B. Jewett Fellowships for 1949–50 to the following: Dr. Harish-Chandra, a graduate in mathematics and theoretical physics of the University of Allahabad, the Indian Institute of Science in Bangalore and the University of Cambridge, who has done considerable research on the theory of elementary particles and is at present working on the theory of Lie algebras at the Institute for Advanced Study, Princeton; Dr. James A. Jenkins, a graduate in mathematics and physics of the University of Toronto and Harvard University, who is engaged in research relating to topological mapping problems at Harvard University; Dr. Robert Karplus, a graduate in chemical physics of Harvard University, who is engaged in nuclear research at the Institute for Advanced Study, Princeton; Dr. Joaquin Mazdak Luttinger, a graduate in physics of Brown University and the Massachusetts Institute of Technology, who has been studying at the Physikalisches Institut, Zurich, and will continue his research there on the theory of the superconductive state; Dr. David Emerson Mann, a graduate in physics and chemistry of the City College of New York and of the University of Chicago, who is engaged in research in quantum mechanics at the University of Minnesota; Dr. Harvey Winston, a graduate in chemistry of Columbia College, who will undertake research in crystallography. These fellowships are designed to stimulate and assist post-doctorate research in the fundamental physical sciences and are awarded on the recommendation of a committee of seven from the Bell Telephone Laboratories. The awards carry a grant of 3,000 dollars to the recipient and 1,500 dollars to the institution at which the research is done.

Textile Institute: Awards

DR. D. A. CLIBBENS, of the British Cotton Industry Research Association, has been made an honorary fellow of the Textile Institute, in recognition of his work on the chemistry of cellulose and the development of analytical and testing methods for the control of bleaching, mercerizing and dyeing. This distinction has only been conferred on eight previous occasions. Dr. S. A. Shorter, formerly of the British Cotton Industry Research Association, has been awarded the Warner Memorial Medal, in recognition of original investigation, the results of which have been published in the *Journal* of the Institute. The Institute Medal, for distinguished services to the textile industry in general and to the Institute in particular, has been awarded to Messrs. A. W. Bayes and Harold Ashton, and the Service Medal, for valuable services rendered to the Institute, to Messrs. H. C. Barnes and S. Kershaw.

Symposium on Engineering Structures at Bristol

THE Colston Research Society has arranged with the University of Bristol a series of symposia, to be held annually, on selected research topics of current importance. The first of these, on cosmic rays, took place last September, and the second, on engineering structures, will be held during September 19–23. At this symposium the papers read will deal mainly with non-linear aspects of the behaviour of engineering structures; but some more general papers reviewing research work on various kinds of engineering structures will be included. A number of men of science, well known in this field, have been invited, and the symposium will be open to all research workers and students connected with this subject. However, the numbers will be limited to eighty, and requests for admission should be sent, before July 1, to Prof. A. G. Pugsley, Merchant Venturers' Technical College, Bristol 1.

The Night Sky in May

FULL moon occurs on May 12d. 12h. 51m., U.T., and new moon on May 27d. 22h. 24m. The following conjunctions with the moon take place: May 6d. 20h., Saturn 3° S.; May 17d. 14h., Jupiter 5° N.; May 26d. 16h., Mars 2° S.; May 27d. 12h., Mercury 0·8° S. Mercury is an evening star, setting at 21h. 10m., 21h. 43m. and 20h. 16m., at the beginning, middle and end of the month, respectively; but in the latter case it is too close to the sun to be observed. The planet attains its greatest eastern elongation on May 10. Venus is an evening star and can be seen for a short time in the western sky after the middle of the month, setting 35 min. and nearly an hour after the sun on May 15 and 31, respectively. Mars is a morning star but rises too soon before the sun for favourable observation. Jupiter rises at 1h. 30m., 0h. 35m. and 23h. 33m., on May 1, 15 and 31, respectively, and is visible for a few hours before sunrise. The planet is stationary on May 20. Saturn is visible until after midnight, setting at 2h. 40m., 1h. 45m. and 0h. 45m., at the beginning, middle and end of the month, respectively, and is stationary on May 1. Only one occultation of stars brighter than magnitude 6 occurs, λ Canc. disappearing at 21h. 30·6m. on May 4.

Announcements

THE L. T. Hobhouse Memorial Trust Lecture will be delivered at King's College, University of London, on May 12, at 5.30 p.m., by Prof. V. Gordon Childe, professor of prehistoric European archæology in the University of London, who will speak on "Social Worlds of Knowledge". Admission will be free, without ticket.

A RESEARCH scholarship of the value of £400 per annum and tenable for two years has been offered by the Aluminium Development Association to encourage and facilitate research in the application of light alloys to ship construction. Full particulars of entry, which closes on July 31, can be obtained from the Secretary, Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Action of Nitrogen Trichloride on Proteins: Progress in the Isolation of the Toxic Factor

PREVIOUS work by Mellanby[1] and Moran[2] has shown that treatment of many proteins with 'Agene' (nitrogen trichloride) produces material which when fed to dogs causes hysteria and epileptiform fits. Radomski, Woodward and Lehman[3] found that rabbits are also sensitive to nitrogen trichloride-treated proteins, and we have found it convenient to employ these animals in preference to dogs since they obviously have considerable advantages in the routine semi-quantitative toxicity assays involved in the course of purification experiments.

We have employed as starting material finely powdered zein treated with nitrogen trichloride at the level of 5·5 mgm./gm. by absorption from a mixture of nitrogen trichloride vapour and chlorine diluted with moist air. 5 gm. of this treated zein is sufficient to produce running fits and convulsions in a 1-kilo rabbit within forty-eight hours. The corresponding amount for a dog is about 25 gm.

The first important point in the purification process is that toxic material can be recovered from treated zein after hydrolysis for three hours in boiling hydrochloric acid (initially 8 *N*). However, it is more convenient, in order to reduce the quantities of material to be processed, first to concentrate the toxic factor by digestion of treated zein with pancreatin. Dialysis through 'Cellophane' separates the toxic factor in the dialysate, which is then extracted successively with water-saturated *n*-butanol at 80° and then with phenol in the cold. The toxic factor remains in the aqueous phase after butanol extraction and is afterwards recovered from the phenol-rich phase. We have made numerous attempts to purify further the phenol-soluble fraction by means of partition chromatography. This fraction is thought to be largely a complex mixture of amino-acids and peptides, and using *n*-butanol as developing solvent on columns of silica gel or starch, the toxic factor is concentrated in a stationary or very slowly moving band, while fast-moving bands can be eluted. Using phenol on columns of silica gel, the toxic factor moves in the fastest-running band. However, considerable losses of toxicity have invariably been encountered on columns of this type, and accordingly it was decided to hydrolyse with acid before attempting any further purification.

Phenol-soluble material is hydrolysed by boiling under reflux for three hours with hydrochloric acid (initially 8 *N*) (the bulk of excess hydrochloric acid removed by repeated evaporation *in vacuo* and the residue redissolved in water), again repeatedly extracted with hot butanol and decolorized with charcoal activated with acetic acid according to the method of Tiselius[4].

The behaviour of this material has been examined in columns of silica gel using phenol as solvent, on anionic resin exchange columns, when subjected to electrodialysis and on fractional precipitation with acetone. These methods have been used individually and in combination; at all stages, fractions have been examined by means of paper chromatography.

A sequence which has been found consistently reproducible is as follows. The decolorized acid solution is brought to 95 per cent acetone concentration, when the toxic factor is distributed between the gummy precipitate and the soluble fraction. The precipitate, redissolved in water, is electrodialysed in a three-compartment cell of the type used by Albanese[5], and the material from the middle compartment is then applied to a resin exchange column ('Zeo-Karb' 215). On elution with ammonia (0·15 *N*) the amino-acids appear in the effluent in the same order as that described by Partridge[6], the toxic factor being eluted in a broad band following proline and extending to the point of the ammonia 'break through'.

When examined on paper chromatograms, the material of the toxic band is found to contain several ninhydrin-reacting substances; namely, proline, a substance *A* (probably methionine) with an R_P value of 0·75, and unidentified substances giving a group of purple spots of R_P values in the range 0·1–0·3 (Whatman No. 4 paper run with phenol). By precipitation with acetone it is possible to remove this last material and still retain toxicity, thus showing that these substances of low R_P value are impurities and cannot be identified with the toxic factor; separate feeding tests confirm that they are non-toxic. Again, when the toxic band is treated by partition chromatography on columns of silica gel, using phenol as solvent, toxic material is obtained both from the fraction first eluted (containing proline and *A*) and also from the slower-moving fraction containing the substances of lower R_P. The inference, therefore, is that the toxic factor cannot be related to any known ninhydrin spot on paper chromatograms. Evidence in support of this, but admittedly not conclusive, is found in the fact that untreated zein degraded and fractionated by exactly the same procedure as above is entirely non-toxic when fed to rabbits, and yet gives a pattern of ninhydrin spots identical with that given by toxic material. Another interesting fact is that when our most concentrated toxic material is hydrolysed by acid under conditions which are normally considered to give complete hydrolysis of protein and peptides, no new ninhydrin-reacting substances are revealed. This would suggest that the toxic factor is not a peptide, unless it is present in amount below the sensitivity of the ninhydrin test.

A rough measure of the progress of purification by the various steps is shown in the accompanying table. The toxic dose refers to the dry weight of the material which will produce convulsive fits in a rabbit of weight approximately one kilo within forty-eight hours.

Step	Fraction	Toxic dose
	Treated zein	5 gm.
Pancreatin digestion	dialysate	1·5 ,,
Butanol extraction	aqueous phase	1·0 ,,
Phenol extraction	phenol phase	0·6 ,,
Acid hydrolysis and butanol extraction	aqueous phase	0·3 ,,
Charcoal and acetone precipitation	precipitate	0·15 ,,
Electrodialysis	middle compartment	30 mgm.
Ion-exchange displacement	end fraction	4 ,,
Acetone precipitation and silica gel	—	2 ,,

The toxicity of our most concentrated material represents, therefore, a 2,500-fold increase on that of the original treated zein.

It should be mentioned that both stages of the last step, precipitation with acetone and recovery from a silica gel column, are not entirely satisfactory as a method of purification, since they are erratic and occasionally involve loss of toxic material. The silica gel column is, however, consistent and reproducible with respect to the known ninhydrin reactants.

Complete isolation and characterization of the toxic factor require operations on a scale larger than has been possible for us hitherto, but these are now in hand.

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A Morphological Distinction between Neurones of the Male and Female, and the Behaviour of the Nucleolar Satellite during Accelerated Nucleoprotein Synthesis

Geneticists have long emphasized that 'maleness' and 'femaleness', so far as chromosome content is concerned, are projected from the fertilized ovum into the morphologically and functionally specialized somatic cells. It appears not to be generally known, however, that the sex of a somatic cell as highly differentiated as a neurone may be detected with no more elaborate equipment than a compound microscope following staining of the tissue by the routine Nissl method.

The observations to be recorded here apply to the cat primarily, since the cat is used routinely in this laboratory for investigations in experimental neurocytology. The nuclei of nerve cells contain a prominent nucleolus which stains readily with such basic dyes as cresyl violet and thionin. The difference in nuclear structure between neurones of adult male and female cats rests on the degree of development of a second body, which is much smaller than the nucleolus. The latter body is more or less intimately associated with the nucleolus and, like the latter, stains well with basic dyes. It has been described by many authors under various names. The term 'nucleolar satellite' will be used in this report, in the hope that students of chromosome morphology will not object too strenuously to the use of the word 'satellite' in this connexion.

Typically, nerve cells of mature *female* cats contain a well-developed nucleolar satellite which is located, as a rule, immediately adjacent to the nucleolus (Fig. 1). A single satellite is usually present; but two may be encountered. The satellite, if more deeply stained than the nucleolus, may be seen in all nerve cells which are sufficiently large to have a prominent nucleolus. More often, the intensity of staining of the nucleolus and its satellite is similar. Under these conditions, the satellite is seen in approximately 30–40 per cent of cells, being invisible when eclipsed by the nucleolus.

As a rule, nerve cells of mature *male* cats (Fig. 2) contain a poorly developed nucleolar satellite, seen only infrequently. When visible, it is situated adjacent to the nucleolus and is near the limit of resolution with an oil-immersion objective.

In a small proportion of animals of both sexes, nucleolar satellites of intermediate size are present. These exceptional cases raise several interesting questions which are now under investigation.

The morphological distinction, therefore, between neurones of the mature male and female cat is so

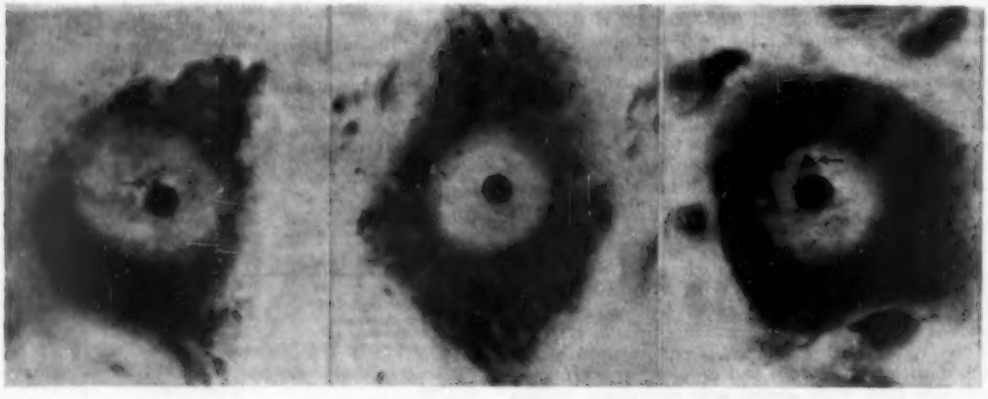

Fig. 1 Fig. 2 Fig. 3

Fig. 1. Normal motor neurone from the hypoglossal nucleus of a mature female cat showing the usual morphology of the nucleolar satellite (indicated by arrow) in the female. Cresyl violet stain, × 1,400

Fig. 2. Motor neurone from the hypoglossal nucleus of a mature male cat. The nucleolar satellite is absent, the typical condition in the mature male. Cresyl violet stain, × 1,400

Fig. 3. Motor neurone from the hypoglossal nucleus of a mature female cat 108 hours following electrical stimulation of the corresponding hypoglossal nerve for a period of 8 hours. Associated with intense synthesis of cytoplasmic ribose nucleoproteins, the nucleolar satellite (indicated by arrow) tends to move away from the nucleolus. Cresyl violet stain, × 1,400

clear that sections from the brain, spinal cord or sympathetic ganglia of animals of both sexes may be readily sorted into two groups without prior knowledge of the sex, with only an occasional section remaining in which the distinctive morphological feature is of an intermediate character.

That there should be a morphological difference in the inter-mitotic nucleus of mature, differentiated cells, according to their sex, is not surprising in view of what is known concerning the relation of the nucleolus to the chromosomes. The nucleolar chromosomes are frequently the sex chromosomes[1]. One may postulate that such is the case in the cat. The nucleolar satellite may be derived from the heterochromatin of the sex chromosomes. Further, the cells of the female cat, because of the duplicated *X*-chromosomes, may be endowed with a greater quantity of nucleolar associated heterochromatin than are the cells of the male cat. Caspersson and Schultz[2] noted a difference in the absorption curves obtained with ultra-violet light, indicating a difference in nucleoprotein content, in cells of male and female *Drosophila*. These comments suggest the importance of taking the sex into consideration in cytochemical studies of nucleoprotein metabolism.

A preliminary examination of sympathetic ganglia of human males and females indicates that a similar sex difference in nuclear morphology exists in the human. Whether or not such sex differences in nuclear structure will be found in a given species would probably be determined, in part, by the relationship of the nucleolus to the sex chromosomes and by the disparity in size and composition between the *X*- and *Y*-chromosomes. It is probable that somatic cells of various tissue, characterized by large nucleoli, will display similar distinctive nuclear differences according to the sex.

We wish to emphasize that these observations apply to mature animals. The influence of the age factor and other aspects of the nucleolar satellite under normal and experimental conditions will be published in later reports.

It is of interest to experimental neurocytologists that the position of the satellite relative to the nucleolus is a useful aid in assessing the physiological state of the cell. In a series of experiments, to be reported in detail elsewhere, depletion of the Nissl material of motor neurones was produced by prolonged electrical stimulation of the hypoglossal nerve. The nucleolus enlarges during the recovery phase, coincident with the re-appearance of abundant Nissl material in the cytoplasm. This observation is in agreement with the views of Caspersson and his co-workers, who regard the nucleolus and the nucleolar associated chromatin as instrumental in the synthesis of ribose nucleoprotein, an important component of the Nissl substance (see Hydén[3] for references). It is of particular interest in the present connexion that the satellite moves away from the nucleolus during the period of intense ribose nucleoprotein synthesis (Fig. 3). The satellite may, in these circumstances, lie in contact with the nuclear membrane. The movement of the nucleolar satellite may be passive, resulting from the outpouring of materials (nucleotides or nucleic acids ?) from the region of the nucleolus. On the other hand, complex factors, such as forces of an electrical nature, may be at work. In any case, the position of the satellite is another item for observation, in addition to the appearance of the Nissl substance, in attempting to assess the physiological state of the neurone under experimental conditions. This criterion may be applied to best advantage, of course, only to the cells of female cats. The nucleolar satellite is occasionally found free in the nucleoplasm in control cells. This is regarded as a further indication of the variation in the physiological state of members of a nerve-cell population under normal conditions.

It is hoped that this brief preliminary report may encourage closer attention to the nucleolar satellite in the abundant material available to laboratories of neuropathology in which the Nissl method is constantly in use as a routine staining technique. The possibility that fundamental alterations in the nucleolar associated chromatin may have an important bearing on malignancy gives added interest to these observations.

These observations were made in the course of experiments on the effect of activity on the neurone being done in this laboratory for the Institute of Aviation Medicine, Royal Canadian Air Force. The senior author wishes to thank various members of the staffs of the Department of Neuropathology, University of Toronto, and of the Montreal Neurological Institute, for very helpful discussions.

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Effect of a South African Native Diet upon Rats

YOUNG rats of the Wistar Institute strain aged five to six weeks and weighing 70–100 gm. were fed on the Gillman diet[1]. This consisted of liberal quantities of a thick mealie-meal porridge and fermented cow's milk. Animals were killed after they had been on this diet for four and a half and six months. All, except two in the latter group, showed an abnormal bromsulphalein retention in the serum; but the serum proteins, thymol turbidity, thymol flocculation and colloidal gold tests were within normal limits.

The following organs were examined histologically: liver, kidney, spleen, upper incisor teeth and periodontal tissues. The lower ends of the radii and ulnæ and the upper ends of the tibiæ were examined by the line test[2]. Microscopy of the livers revealed relatively little fatty change, but practically complete absence of glycogen in all except the two rats, which showed a normal bromsulphalein excretion. In these two rats the amount of glycogen present in the liver was normal. The kidneys and spleens of all animals showed no abnormal histological changes. Interesting pathological changes were, however, found in the incisor teeth and periodontal tissues, which are best described under three heads.

(1) The animals were suffering from a sub-acute vitamin A deficiency, which was not severe after four and a half months, but was much more marked after six months. This was seen in the teeth of the younger rats as a lack of regression of the odontoblasts, which

became included in the dentin, especially on the lingual side, the predentin eventually disappearing. This phenomenon was seen on both sides of the teeth in the older rats; in addition, these teeth showed an atrophy of the odontoblasts on the lingual side at the formative end and a subnormal production of dentin, together with over-production of dentin on the labial side; apposition instead of resorption was found on the periodontal side of the premaxillary labial alveolar bone, which is also typical of vitamin A deficiency[3]. The only microscopic change characteristic of vitamin A deficiency which was not present was keratinization of the naso-lacrimal duct epithelium; but in long-standing sub-acute vitamin A deficiency this sometimes does not occur. In some of the older rats a chronic infection was present, as shown by an invasion of small round cells, plasma cells, eosinophils, macrophages, etc., in the mucous glands at the formative end of the tooth and elsewhere. The lingual dentin at the incisal end of the tooth of one of the older rats contained Gram-positive and -negative cocci, and the underlying pulp had an inflammatory reaction. The organisms were found in the dentin tubules and in the cavities containing the vascular and cellular inclusions. Externally, the animals showed no signs of vitamin A deficiency, and the teeth had kept their orange pigment.

(2) A rachitic condition was present, seen as an extreme widening of the predentin on both sides of the tooth. In the older animals some healing had occurred. The epiphyseal cartilages of the long bones were not wider than usual, and the fundic bone of the alveolus was also normal, so that it would appear that this rickets was of the low-calcium type. This surmise is supported by the fact that the calculated calcium and phosphorus contents of the diet were 0·057 and 0·16 per cent respectively, with a Ca : P ratio of 0·36.

(3) In all rats, but especially in the older ones, the enamel organ and particularly the ameloblasts showed early and abnormal atrophy. This was accompanied by the presence of many macrophages in the labial alveolar periosteum, especially towards the incisal end of the tooth. In the younger rats, these cells contained a few granules; but in the older animals they were laden with many conspicuous granules. In the older rats, the pigment layer of the enamel persisted, after removal of the rest of the enamel during the histological decalcification process. It was attached to the enamel organ, from the level of the granule-containing ameloblasts up to the alveolar crest, and the granule-containing ameloblasts were usually conspicuous. Tests for iron were positive for this pigmented layer, for the granules in the macrophages and for those in the ameloblasts. It seems almost certain that the granules in the macrophages were the same in composition as the pigmented enamel. Chase[4] has described an invasion of macrophages in conditions where the enamel organ was degenerative, and we have also seen this in other specimens where the enamel organ was atrophying from a variety of causes, but never so markedly as here.

From the evidence of the teeth it seems that a multiple deficiency was present. It is possible that the vitamin A or vitamin A precursors present in the two constituents of the diet were partially destroyed by oxidative processes when the ingredients were mixed together, especially when fermented milk was used. Györgyi[5] has reported that vitamin E prevents the hepatic injury caused by certain deficient diets, and vitamin E is known to afford protection to carotene[6]. However, no correlation at all was found between the tooth changes and the alterations in the bromsulphalein serum retentions in the present experiments; this does not support the proposition that both are caused by the same deficiency. The rachitic condition is explained by the very low calcium and phosphate contents of the diet and by the abnormally low Ca : P ratio. The changes in the pigment layer of the enamel have not been described before, and are being further investigated.

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A New Mutant in the Progeny of Mice Treated with Nitrogen Mustard

The ability of the mustard compounds to induce gene mutations and chromosome re-arrangements was first detected in experiments with *Drosophila melanogaster*[1–3]. Subsequent investigators showed that this ability extends to all organisms which so far have been tested: *Neurospora*[4], *Tradescantia*[5], *Penicillium*[6], barley[7], bacteria[8] and *Vicia*[9]. There can be little doubt that the mutagenic ability of the mustards is as general as that of X-rays. On the other hand, there is no *a priori* reason for assuming that mustards applied to other organisms will exhibit the same peculiarities of genetical effect which have been found in the work with *Drosophila*, namely, a relative shortage of large re-arrangements[8], deferred action[10,11], and preferential action on immature sperm[12].

It seems worth while to study mustard effects in different species from this point of view. For obvious reasons warm-blooded animals, in particular mammals, are of special interest. It is known that in mammals also mustard gas acts as mitotic poison[13]. This selective action on dividing cells is made use of in the therapeutic treatment of leukæmia and Hodgkin's disease[14]. Proper tests for the production of mutations and chromosome re-arrangements in mammals have, however, not yet been attempted. Apart from their theoretical interest, such tests might acquire practical significance, if in future it should become possible to use nitrogen mustards not only as a palliative in malignant disease, but also to effect more or less permanent cures; for in such cases it would be important to assess the effect of the treatment on the gonads of a patient who afterwards may be able to reproduce.

We have recently started experiments in which male mice of an inbred wild-type strain are treated

with a nitrogen mustard (N-methyl di-(2-chloroethyl)-amine), and the progeny are tested for translocations (heritable semi-sterility) and visible mutations. In the first three experiments, twelve mice were each given 0·08 mgm. by intraperitoneal injection. All but one died within a few days. Some of the mice of the third experiment mated before death and produced litters of normal size. Nine of their sons were tested for semi-sterility with negative results. In the second experiment, two out of three treated mice died without progeny. The third survived and mated at least once in the week following treatment. No offspring, however, were produced until about two months later, when full fertility was restored. Of the twenty-four offspring born, sixteen were tested for the presence of recessive gene-mutations by outcrossing each and then backcrossing the offspring to them or mating the offspring *inter se*. In one of these matings a hitherto unknown mutant in its first litter was segregated.

Only a very brief description of the new mutant can be given here. It appears to be due to a single recessive gene, giving normal ratios and having full penetrance. Its visible effects on the mouse are many: the most striking are a peculiar folding of the ears from about one to three weeks of age, absence of hairs on the tail and behind the ears, small kinks at the extreme tip of the tail, and a short and rather thin coat with the hairs tending to point toward the midline of the back. These effects are all very regular in their appearance, except the thinness of the coat, which varies somewhat. Both sexes are fertile, and the females are able to rear their young.

The occurrence of one mutant cannot, of course, be certainly ascribed to the mutagenic action of the treatment, even considering the small number of gametes tested. The discovery of spontaneous visible mutations in mice is, however, a very rare event, even in inbred lines, and the discovery of one among sixteen gametes seems to be extremely improbable. In fact, not all the sixteen gametes were adequately tested. It was calculated, by a method described elsewhere[15], that the equivalent number of fully tested gametes was only 11·3. It seems, therefore, more likely that the mutation was induced than spontaneous, and the experiments are being continued.

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Tissue Distribution of a Radioactive Spinal Anæsthetic

WHEN a spinal anæsthetic leaves the subarachnoid space and the neural elements contained therein, it enters the general circulation, by which agency it is distributed among the various tissues of the body. Hitherto, on account of the technical difficulties attendant upon the estimation of an anæsthetic substance at low concentration in the presence of gross tissue excess, precise studies of tissue distribution have not been made.

To investigate various problems associated with local and spinal anæsthesia, I prepared a radioactive anæsthetic, dibromoprocaine hydrobromide[1]. For the purpose in hand, a reasonably active preparation was requisite, and this was obtained by irradiation in the chain-reacting pile of 30 c.c. of ethylene dibromide containing 5 per cent of aniline[2], followed by a modified Szilard–Chalmers's extraction. The radioactive bromine finally obtained as silver bromide was treated in the manner previously described[1] and the product dibromoprocaine hydrobromide converted into dibromoprocaine hydrochloride, so as to eliminate the ionizable bromine.

The established pharmacology of the nuclear halogens indicates that the bromine atoms are not likely to be split from the benzene nucleus in the course of its metabolism, and I have confirmed this. Consequently the estimation of the radioactivity of specimens derived from the various tissues should provide an index of the concentrations of the original drug in terms of its benzene nuclei, notwithstanding any further additions which may be made to it during its sojourn in the body, and the fate of the side chain.

Cats were employed in the first series of experiments, and these received, by lumbar puncture, doses of dibromoprocaine hydrochloride varying between 0·007 and 0·03 gm. Urine was obtained by catheterization, cerebrospinal fluid by lumbar puncture, bile by aspiration of the gall bladder and blood by cannulation of the carotid artery or ventricular puncture. Autopsies were performed at periods of 1–39 hr. after the administration of the anæsthetic, and specimens taken from the organs to be examined. The tissue samples so obtained were broken down in lithium hydroxide solution under reflux, and the resulting fine suspensions estimated by means of a scaling unit and 'liquid' counter.

In the second series, the anæsthetic was administered intravenously, so as to study the effects on tissue concentration of higher blood levels.

In the intrathecal series, the blood levels fell between 5·4 and 1·3 μgm. per c.c., while, in the case of the intravenous series, maximum blood levels of 44 μgm. per c.c. were investigated.

The tissues examined were skin, kidney, liver, duodenum, spleen, muscle, lung, testis, thyroid, spinal cord, spinal roots, medulla oblongata and sciatic nerve. Estimations of urine, bile and duodenal contents, cerebrospinal fluid and fæces were also made.

Apart from spinal cord and spinal roots, only kidney and liver showed a concentration of the drug above that obtaining in the blood, the former reaching a maximum of 9 times and the latter 3 times the blood concentration; while their secretions, urine and bile, showed maximal concentrations of 133 times and 27 times that of the blood respectively; the concentration of the drug in the duodenal contents

followed that of the bile. Investigation of the fæces showed that part at least of the dibromoprocaine molecule was excreted *via* the gut.

The concentrations of anæsthetic in spinal cord, roots and cerebrospinal fluid were not directly dependent on blood concentration, since the drug was administered by lumbar puncture. It is of interest, however, that the spinal roots showed a higher concentration of anæsthetic per unit mass than did the cerebrospinal fluid in which they were bathed.

As regards the drug content of the remaining tissues, the lung showed the highest and muscle tissue (gastrocnemius) the lowest, attaining 0·8 and 0·1 times blood concentration respectively: the other tissues fell between these two limits.

With increased time between administration and autopsy, a slight increase in the blood-tissue ratios was observed, due, probably, to leakage from the vascular bed of the organs to the tissues themselves; this effect was maximal about twenty hours after administration of the spinal anæsthetic, with subsequent steady decline. In the case of the liver and kidney, tissue concentration was greatest about 1½ hr. after injecting the drug, at which time blood and bile concentrations were also maximal.

When the drug was given intravenously, the cerebrospinal fluid in the lumbar theca showed a barely estimable amount of tracer, while the cord showed 0·05–0·1 times and the roots 0·3–0·4 times blood concentration.

At high blood levels, the concentrating activity of liver and kidney appeared to decrease, due presumably to a 'swamping' of these organs; but variations in blood levels had little effect on the blood-tissue ratios elsewhere. Tracer could be detected in the circulation at considerable intervals (70 hr.) after its administration, and, at this period, both liver and kidney concentrations were also observed to drop, in spite of a persistent blood level at which active concentration had previously occurred.

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Epidermal Mitosis in Relation to Sugar and Phosphate

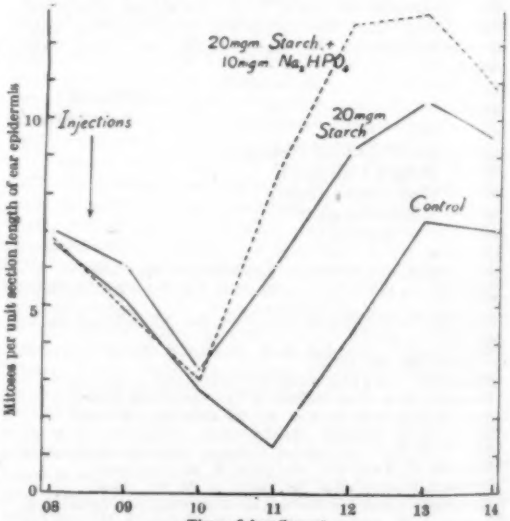
DESCRIPTIONS have been given of the diurnal mitosis cycles in the ear epidermis of the adult male mouse, and the conclusion has been reached that the form of these cycles is determined by the daily routine of activity and of rest[1]. During bodily activity, the mitosis-rate is low, and during sleep and rest it is high. In extending these observations, two further important facts were noticed, namely, that excessive muscular exercise is followed by an abnormal depression of the mitosis-rate[2], and more recently, that the same effect can be induced by extreme cold. Since in both these situations there is a drain on the sugar reserves of the body, in the one case for muscle contraction and in the other for heat production, it was suspected that an abundance of sugar may be a critical factor in the development of a high mitosis-rate.

After preliminary experiments, the following method of administering extra sugar to a mouse was adopted. A subcutaneous injection of a solution of 20 mgm. of starch in normal saline was given to each animal at 08.30 hr. This resulted in a steep rise in the concentration of the blood sugar, which reached a maximum at about 10.00 hr. and returned to normal soon after midday. The accompanying changes in the epidermal mitotic activity were followed by the removal of pieces of ear at hourly intervals from 08.00 to 14.00 hr., and typical results from one of these experiments are shown in the accompanying table. It should be noted that only male mice were used in order to avoid the effects of the œstrous cycle. The results show clearly that a marked stimulation of mitotic activity followed the injection of the starch. There was a time lag of about 1½ hr. before the effect began to develop, but after that the rise in mitotic activity was rapid. The later and smaller rise in the mitotic activity of the control mice was due to the effect of the afternoon sleep period.

Variations in the mitotic activity of the ear epidermis following injections of starch alone and of injections of starch together with disodium hydrogen phosphate at 08·30 hr.

Time of day	No. of observations per group	Av. numbers of mitoses per cm. length of sections cut 7 μ thick		
		of 10 control mice injected with saline alone	of 10 mice injected with 20 mgm. of starch in saline	of 10 mice injected with 20 mgm. of starch and 10 mgm. of $Na_2HPO_4.2H_2O$ in saline
08·00	10	6·6 ± 0·19	7·0 ± 0·11	6·7 ± 0·12
09·00	100	5·1 ± 0·18	6·1 ± 0·11	4·9 ± 0·10
10·00	100	2·7 ± 0·06	3·3 ± 0·08	3·1 ± 0·09
11·00	100	1·3 ± 0·05	6·1 ± 0·19	8·5 ± 0·14
12·00	100	4·0 ± 0·10	9·4 ± 0·14	12·6 ± 0·21
13·00	100	7·3 ± 0·15	10·5 ± 0·12	12·8 ± 0·25
14·00	100	7·0 ± 0·14	9·5 ± 0·16	10·8 ± 0·18

The most plausible theory of the function of sugar in stimulating mitotic activity seems to be that it acts as a source of energy. This being so, it might be expected that interference with the process of phosphorylation by means of phloridzin injections would depress mitotic activity, and this has, in fact, been



The variations in the mitotic activity of the ear epidermis of adult male mice following injections of starch and of starch together with disodium hydrogen phosphate

confirmed. Conversely, it might also be expected that by injecting phosphate together with starch an even greater mitosis stimulation would be achieved. That this also is the case is shown in the table and in the graph.

This demonstration of the importance of sugar to the process of cell division sheds light on several well-known phenomena, of which the following may be selected for comment. It is common knowledge that the vaginal epithelium becomes charged with glycogen, and produces what appears to be lactic acid, at about the time when it develops high mitotic activity in response to œstrogenic stimulation[3]. Similarly, it has been shown[4] that the administration of œstrogens causes a considerable increase in the blood-sugar level, in apparent preparation for the wave of mitotic activity which follows such treatment. Finally, it is also appropriate to notice here that the induction of a hyperglycæmic condition in canaries favours the rapid multiplication of the malarial parasite *Plasmodium cathemerium*, with a consequent increased death-rate among the hosts[5]. Conversely, in canaries made hypoglycæmic with insulin, fewer parasites develop and larger numbers of the birds survive the infection. During the present work it has also been demonstrated that a reduction in the blood-sugar level following injections of insulin is accompanied by a severe depression of epidermal mitotic activity. All these observations are being published in full elsewhere.

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Relation of Molybdenum and Manganese to the Free Amino-Acid Content of the Cauliflower

Molybdenum[1,2] and manganese[3,4] are both believed to be concerned in the chain of reactions beginning with the reduction of nitrates and ending in protein assimilation in higher plants, although they may also have other functions. It has been shown that lack of either element may result in a marked accumulation of nitrates in the leaves of plants. 'Soluble nitrogen' and protein nitrogen fractions also may be less when molybdenum is withheld, but may be nearly normal in the absence of molybdenum when ammonium sulphate is used instead of nitrate as a source of nitrogen[2]. A relationship between manganese and molybdenum has been reported for flax grown in water culture[5,6], where the harmful effects of excess of manganese (and of certain other metals) were reduced by additional amounts of molybdenum.

As there is no evidence that either of these elements can replace the other, it may be assumed that they act independently in the chain of reactions occurring between nitrate reduction and protein formation.

The present note gives preliminary results of experiments designed to study the interrelationships of molybdenum and manganese and to obtain evidence of the reactions catalysed by these elements and their sequence.

Cauliflower plants, variety Majestic, were grown in sand culture using the technique already described[1], with three levels each of molybdenum (nil, 0·015 and 9·5 p.p.m.) and of manganese (0·0055, 0·55 and 55 p.p.m.), ranging for each element from deficiency through normal to toxicity. These plants provided material for the study of nitrate accumulation, as determined on fresh tissue extracts[7], and of the free amino-acid present in the 70 per cent alcoholic extracts of partly expanded leaves. The presence of amino-acids was followed by paper chromatography[8], as recently applied to plant tissues by Dent *et al.*[9] and by Allsopp[10]. Preliminary one-dimensional chromatograms (phenol as solvent) showed variations in amino-acid content quite clearly. Two-dimensional chromatograms (phenol and collidine as successive solvents) permitted identification of several amino-acids[9] by comparison with control runs using known mixtures. The relative concentrations of the amino-acids thus detected were assessed visually in terms of the intensity and area of the colour produced with ninhydrin.

Nitrate accumulated to abnormally high concentrations when either element was deficient, and in this respect the low concentration of manganese appeared to be more conducive to nitrate accumulation than that of molybdenum—an element known to be required in far smaller amounts. Molybdenum deficiency resulted in a marked reduction in the concentrations of most amino-acids, while a few were scarcely affected. The effects of molybdenum and manganese on the free amino-acid content of the leaves were found to be interdependent. Generally a decrease in the molybdenum-level was paralleled by a reduction in the amino-acid concentration, while a similar change of manganese-level acted in the opposite direction, that is, a deficiency of manganese was associated with an increase in amino-acid concentration. The effect of change in molybdenum-level was most marked under conditions of manganese deficiency, while change in manganese-level showed the greatest effect in the presence of a high level of molybdenum.

These changes were particularly great for arginine and were also pronounced with alanine, aspartic and glutamic acids, proline, and an unidentified acid or possibly peptide. The acid amides, asparagine and glutamine, showed similar changes. Another unidentified amino-acid or peptide, however, showed an opposite effect with respect to manganese and appeared more strongly in the presence of an excess of this element. The amounts of some amino-acids were only affected by molybdenum variations from deficiency to normal levels, but for others the effective range lay between the normal and excess levels. Arginine, proline and one of the unidentified substances, however, showed variations over the whole range of molybdenum concentrations. These interdependent effects and the fact that nitrate accumulates in the absence of either molybdenum or manganese may ultimately be explained in terms of the kinetics and mass-action laws of the respective reactions controlled by each element.

The evidence so far available is, however, consistent with the hypothesis that molybdenum and manganese catalyse separate reactions, both of which affect the concentration of amino-acids as intermediate metabolites in nitrogen metabolism. The evidence also suggests that whereas molybdenum controls one or more reactions leading from nitrate to amino-acid production, manganese may function

later in the chain when amino-acids already produced are further metabolized.

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Tellina magna found in Orkney

During Easter 1947, an inspection was made of the seaweed cast up on the west mainland of Orkney. One heavy cast, 3 ft. thick at the water's edge, was found in a sandy bay north of the graveyard north-west of Stromness and opposite the northern extremity of Hoy. The coast is rocky with sandy bays. The rocks are Old Red Sandstone, which erode to form flat slabs sloping towards the sea. About half a mile offshore, a reef of similar rock formation is exposed at low water. There is little chance of anything remaining intact before being cast ashore as the Atlantic waters break on this coast.

The cast weed on this occasion, composed mainly of the fronds of *Laminaria Cloustoni*, had acted as a buffer for several large shells, such as *Pecten*, which were found intact. Normally, such shells become so broken up that they merely add to the shell sand comprising the foreshore in this area.

From among the cast weed a bivalve, 4 in. long, was picked up which when discovered had its two halves hinged; the contents were absent. It has now been identified as *Tellina magna*, a native of the East American coast, North Carolina to West Indies—and is, I am informed, the first recorded instance of a marine invertebrate from the American continent to be found in British waters. Subsequent visits to the same area have produced only limpet shells and one small bivalve. There can be no doubt the cast weed was responsible for bringing the shell ashore intact. How the animal (or its ancestors) crossed the Atlantic can only be speculation. Whether living specimens are to be found off this Orkney coast a dredging expedition must decide.

I wish to acknowledge the interest of the late Mr. R. Elmhirst, of the Marine Biological Station, Millport, Prof. C. M. Yonge, of the University of Glasgow, and Dr. A. C. Stephens, of the Royal Scottish Museum, who were responsible for the identification.

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Nuclear Capture of μ-Mesons

It is well known from delayed-coincidence experiments[1] that negative μ-mesons (mass 215) stopping in light atoms undergo electron decay, whereas those stopping in substances of high atomic number undergo nuclear capture. Both photographic plate[2,3] and cloud-chamber evidence[4,5] shows that very few or none of the μ^--mesons produce nuclear disintegration stars in heavy elements. Counter-work[6] precludes production of photons, though there is evidence for emission of neutrons following meson capture[7,8]. It is of interest to discuss the above evidence in the light of observations on μ-mesons stopping in nuclear emulsions.

The emulsion consists of microcrystals of silver bromide, about $0{\cdot}2\,\mu$ in diameter, suspended in gelatin. Thus, a meson coming to rest in the emulsion will, in general, spend the last fraction of a micron of its range either entirely within heavy atoms, or in light ones. Hence the probability of the meson stopping in heavy or light atoms will be almost independent of the complicated processes of energy-loss below a velocity of about 5×10^9 cm./sec., and can be estimated from experimental data on stopping power. Allowing a positive excess of 15 per cent, we thus calculate that the proportion of mesons which are negative μ-mesons stopping in silver or bromine atoms is 35 per cent. In Kodak electron-sensitive plates exposed to cosmic rays, we in fact observe that 30 ± 6 per cent of the single mesons (the great majority of which are known to be μg particles[3]) fail to give a decay electron on coming to rest. This figure is in good agreement with that obtained by other observers[9].

First of all, it is clear that, quite apart from the fact that it is contrary to the concept of short-range nuclear forces, the rest-energy of the μ-meson cannot be shared directly among several nucleons, otherwise we should inevitably observe fast protons emitted. Let us suppose that the entire rest-energy of the μ-meson is converted into kinetic energy of (*a*) two, and (*b*) one fast neutron. Process (*a*), which is the same as that which probably occurs following negative π-meson capture[3], should result in many cases in the formation of a star, for it is difficult to see how at least one of the neutrons can avoid producing general nuclear excitation and evaporation. If, as seems extremely unlikely, the latter did not occur, half the resulting palladium or selenium isotopes would be stable, and the remainder would probably be β-active[10]. If these were short-lived isotopes, the proportion of mesons not giving electrons would be greatly reduced. The β-particles would also be immediately distinguishable on account of their small momenta. In actual fact, the momenta of the decay electrons, obtained from Coulomb scattering measurements, appear in all cases to exceed 10 MeV./c. (Where accurate measurements on long tracks are possible, the observed values are much higher than this[9].) Thus any β-decay which might occur would have to be fairly long-lived. In this connexion, it is interesting to note that we have observed no significant difference between the proportion of mesons not giving electrons in plates exposed for six days at Jungfraujoch and developed four days later, and those in plates exposed for three weeks and developed one month later.

In process (*b*) the nucleus (which will be stable to β-decay) must take up the momentum of the neutron, amounting to 450 MeV./c., and will have a range in

the emulsion of 1·7 μ [11]. However, from fifteen mesons in Kodak plates not giving decay electrons, we observe only two tracks which could possibly be attributed to recoils. An accurate estimate of the number of such recoils is difficult to obtain because their tracks can easily be confused with Coulomb scattering at the very end of the meson track. We obtain an *upper* limit if we double the number of apparent recoils travelling backwards with respect to the general direction of the meson.

Observations were therefore made on single mesons stopping in fine-grain plates (Ilford *C*2, not capable of recording decay electrons). From 190 meson tracks examined (about sixty of which would be negative μ-mesons stopping in heavy atoms), only eight recoil tracks of ranges of the above order of magnitude were obtained. If all gave recoils, thirty would be backwards and we should expect many more than eight of these to be definitely observable. About one-seventh of the mesons stopping in our plates are π⁻-mesons producing stars. A further quarter of all the π⁻-mesons are known to be captured in heavy nuclei and give rise to emission of neutrons only[2] (apart from a recoil); these will be classified as single mesons. They constitute about 5 per cent of all the single mesons and can thus account for at least half the observed recoils; the remainder can be quite reasonably attributed to large-angle Coulomb scattering along the meson tracks. This analysis demonstrates the absence of a homogeneous group of recoil tracks of range ~ 1·7 μ, indicating that the resultant momentum of a nucleus capturing a μ⁻-meson must be ≪ 450 MeV./c. The minimum length of recoil observable is estimated at 0·5 μ, corresponding to a recoil momentum of 150 MeV./c.

We must therefore assume that part of the rest energy of the meson is converted into kinetic and rest energy of a light neutral particle. If the remainder appears as kinetic energy of a single neutron, the maximum energy the latter could have, to make the nuclear recoil just unobservable, would be 25 MeV. It is extremely unlikely that a neutron of such low energy would give rise to charged-particle emission in traversing the nucleus, but one or two further neutrons might be evaporated off[12].

Thus, so far as the experimental data permit, we can conclude that the capture of a μ⁻-meson by a heavy nucleus leads to the process

$$\mu^- + P \rightarrow N + \nu,$$

where ν denotes a light neutral particle (neutrino ?). This is precisely the interaction predicted theoretically[13] as a consequence of the μ-decay of the π-meson, assumed to be of the form $\pi \rightarrow \mu + \nu$.

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Electron–Atom Ratios in Alloy Phases as a Monotonic Sequence

1/1, 3/2, 5/3, 7/4, 9/5, 11/6, 13/7 . . . $(2n'-1)/n$ . . . 2/1 is a monotonic sequence[1] tending to the limiting value 2/1 when n is increased indefinitely. This sequence is a systematic representation of the ratio of the number of free valency electrons to atoms in the well-known Hume-Rothery[2] series of electronic compounds.

For example, in the copper–zinc system, where copper is regarded as monovalent and zinc is divalent, we should have a series of improper fractions, each conforming to the above sequence, and each corresponding to a different phase (see Table 1).

Table 1

Designation	α	β	γ	ε	η
Electron/atom ratio—Ve/A	1/1	3/2	5/3	7/4	2/1
Empirical formula	Cu	CuZn	$CuZn_3$	$CuZn_8$	Zn
Atomic % Zn	0	50	66·7	75	100
True limits of phase field (400° C.)	0 37	45 49	57 67	77 87	97 100
Crystal structure	f.c.c.	b.c.c.	'γ' type	h.c.p. $c/a = 1·55$	h.c.p. $c/a = 1·86$
Structural formula	Cu	CuZn	Cu_5Zn_8 Cu_9Zn_{31}		Zn

In each case the simple formulæ given in the third row fit in well enough with the respective limits of composition, although they are, of course, empirical in origin and are not necessarily related to the crystal structures. The composition limits are decided in other ways, for example, by the free-energy relations between neighbouring phases or by the Brillouin zone theory[3], which does not, however, give rise to any integral values, serving as a rule merely to fix an upper limit to the electronic concentration. For example, the α-phase (face-centred cubic) becomes unstable about the composition limit corresponding to $Ve/A = 1·36$ (36 atomic per cent zinc), while the β-phase (body-centred cubic) agrees with $Ve/A = 1·48$ (48 atomic per cent zinc).

The range of the ε-phase (hexagonal close-packed) varies greatly from system to system. However, the ratio 7/4 is usually regarded as typical and receives support on theoretical grounds.

An even more striking illustration of a monotonic sequence is afforded by the copper–aluminium system, as can readily be shown. It now appears that in addition to the typical γ-phase (analogous to γ-brass) there are three other closely related phases, two (γ_1 and γ_2) being obtained at room temperature[4], while ε is got by quenching[5]. Further, there is a phase beyond this region (ξ) which has many structural similarities to the γ-phase. Ultimately this complicated region in the equilibrium diagram concludes with the η-phase (CuAl). There are, in all, eight different structures with from one to two free valency electrons per atom. Within each of these phase fields, the ratio of the numbers of free valency electrons to atoms may be represented by the equation $Ve/A = (2n - 1)/n$. Table 2 shows how well the monotonic relationship is observed.

The empirical formulæ $CuZn_3$ and Cu_9Al here allotted to the γ-phase are included well within the respective composition limits of these phases, although they do not correspond with the theoretical atomic distribution, which must conform with a unit cell of 52 atoms.

Table 2

Designation	α	β	γ	γ_1	γ_2	ε	ζ	η
Electron/atom ratio = Ve/A	1/1	3/2	5/3	7/4	9/5	11/6	13/7	2/1
Empirical formula	Cu	Cu_3Al	Cu_5Al_8	Cu_9Al_4	$Cu_{31}Al_8$	Cu_7Al_3	Cu_9Al_4	CuAl
Atomic % Al	0	25	33·3	37·5	40	41·7	42·9	50
True limits of phase field	0	25	31·5	35·4	38·3	Inc.		less than 50
	20	approx.	35·2	38·0	40·2			
Crystal structure	f.c.c.	b.c.c.	type	Deformed 'γ'		Related to γ		
Structural formula	Cu	Cu_3Al	Cu_5Al_8	$Cu_{31}Al_{10}$	$Cu_{39}Al_{10}$			
			$Cu_{21}Al_8$					
Space group			$P\bar{4}3m$	Cm	$R3m$			

For this reason, Cu_5Zn_8 and Cu_9Al_4 are preferred to the empirical formulæ, giving in both instances the somewhat lower ratio $Ve/A = 21/13$ (1·615 instead of 1·667).

However, the exact composition for Cu_9Al_4 is a two-phase alloy ($\alpha + \gamma$), showing that the crystal structure is not a decisive factor in fixing the phase boundaries. According to Konobeevsky[5], the exact upper limit for the γ-phase at $Cu_{17}Al_8$ corresponds to the complete filling of the first Brillouin zone, which is limited by the crystallographic planes (330) and (411). It is interesting to note that the approximate upper limit for γ-brass also agrees with a ratio $Ve/A = 22/13$, the appropriate formula being Cu_4Zn_9.

Thus we have in addition to the empirical formulæ ($CuZn_3$ and Cu_3Al) both upper and lower limiting values for the phases. The corresponding formulæ (Cu_5Zn_8—Cu_3Zn_8 and Cu_9Al_4—$Cu_{17}Al_8$) indicate that the ratio Ve/A lies between 21/13 and 22/13.

Conclusion. There is a tendency for many alloy phases to occur when the ratio of the number of free valency electrons agrees with the monotonic sequence $(2n - 1)/n$, where $n = 1, 2, 3, 4, 5, 6, 7$. The characteristic ratio for the γ-phases would then be 5/3 instead of 21/13, although the crystal structures of Cu_5Zn_8 and Cu_9Al_4 require the latter value, while the upper limiting compositions Cu_4Zn_9 and $Cu_{17}Al_8$ point to the higher value 22/13. A publication will appear shortly to show why the ratios 21/13 and 22/13 are so very important.

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Flow of Adsorbed Molecules

Just as Knudsen and others[1] have shown for single capillaries, flow of a gas through a porous medium also undergoes a transition from viscous flow to molecular flow when pore diameters become comparable in size with the mean free path of the gaseous molecules. The position has been reviewed recently[2], but more data in the molecular flow region are desirable. I have therefore been studying the flow of various gases through plugs of 'Linde silica', a finely divided, amorphous silica stated by the makers to have a maximum particle size of 0·05 μ. The experiments cited here were carried out on a single plug compressed to a porosity (ε) of 0·678. The specific surface, S_0, calculated from the permeability equation of Carman and Arnell[3], was $2{\cdot}35 \times 10^4$ cm.^{2}/cm.^{3}. This gives an equivalent pore diameter $\frac{4\varepsilon}{(1-\varepsilon)S_0} = 3{\cdot}6 \times 10^{-6}$ cm., which was usually well below the mean free path of the various gases studied. Application of the Brunauer–Emmett–Teller calculation[3] to gas adsorption isotherms gave $S_0 = 2{\cdot}8 \times 10^4$ to $4{\cdot}1 \times 10^4$ cm.^{2}/cm.^{3}, indicating that particles possibly possess an internal surface which is not accessible to flow. To cover a wide range of molecular weights, flow-rates were measured at 22° C. for hydrogen, air, carbon dioxide and 'Freon-12', CF_2Cl_2, all of which gave consistent values for S_0.

The flow-rate for sulphur dioxide, however, was distinctly higher than expected. The boiling point of sulphur dioxide is such that it is appreciably adsorbed at 22° C., and it was suspected that this might be responsible. Further experiments were therefore carried out at 0° C., and the results, summarized in the accompanying table, seem to show clearly that the difference between observed permeabilities and those calculated on the assumption that $S_0 = 2{\cdot}35 \times 10^4$ cm.^{2}/cm.^{3} does depend on adsorption. Permeabilities are given by $pQL/A\,\Delta p$, where Q is rate of flow in cm.^{3}/sec., measured at the mean pressure $p = (p_1 + p_2)/2$, at the temperature of the plug, L cm. and A cm.^{2} are length and cross-section of the plug, and Δp is pressure difference across it. The pressure, p_1, on one side of the plug, was always atmospheric (about 660 mm. at Pretoria), while p_2 was varied and could be either greater or smaller than p_1. Adsorption was also measured, and has been expressed as v cm.^{3} of liquid sulphur dioxide adsorbed per cm.^{3} of plug, assuming density of adsorbed sulphur dioxide is equal to that of the liquid in bulk, that is, it gives the pore-space occupied by liquid sulphur dioxide. The value in brackets for $p_2 = 1{,}160$ cm. at 0° C. is assumed, on the basis that the pore-space is filled by condensed sulphur dioxide. At $p_1 = 660$ mm., corresponding values for adsorption are 0·039 at 22° C. and 0·072 at 0° C. From these, the values $\Delta v/\Delta p$ have been calculated in the last column of the table.

Temperatures (° C.)	p_2 (mm.)	Calculated permeability $\times 10^5$	Observed permeability $\times 10^5$	Pore space occupied by adsorbed SO_2 at p_2	$\frac{\Delta v}{\Delta p} \times 10^6$
22	83	1·17	1·40	0·012	4·7
22	1331	1·25	1·47	0·064	3·9
0	44	1·13	1·52	0·013	9·6
0	90	1·14	1·54	0·020	8·8
0	896	1·19	1·77	0·108	15·2
0	935	1·19	1·88	0·118	17·0
0	1067	1·20	2·16	0·234	40·2
0	1160	1·21	4·28	(0·68)	(121)
0	1300	1·22	1·57	—	—

The most remarkable feature is the extremely rapid increase in permeability at 0° C. as the saturation vapour pressure of liquid sulphur dioxide, 1,161 mm., is approached; especially since one would expect the volume occupied by adsorbed sulphur dioxide to restrict flow in the gas phase. Presumably, the reason is that the concentration gradient in the adsorbed film increases much more quickly than the pressure drop across the plug in this region, as shown by $\Delta v/\Delta p$.

The mobility observed for the adsorbed layer could not be predicted from the properties of liquid sulphur dioxide. If pores were wholly filled with the liquid, and the permeability is calculated from its viscosity, it is found to be of the order of 5×10^{-4} times the calculated gaseous permeability, that is, liquid sulphur dioxide should block the pore-space. Evidence favouring this is that, when $p_2 = 1{,}300$ mm., the initial permeability is still faster than for $p_2 = 1{,}160$ mm., but decreases steadily over many hours to the relatively low value cited. Presumably, the high-pressure side of the plug becomes choked with condensed sulphur dioxide, which evaporates as it flows to the low-pressure side.

These observations bear out those of Tomlinson and Flood[4], who studied the flow of diethyl ether and ethyl chloride vapours through rods of activated charcoal. These workers did not observe the rapid increase of permeability near the saturation pressure of the vapours, but did note that the difference between observed and calculated permeabilities increased at low values of the mean pressure. This is not unreasonable, since the gradient of an isotherm adsorption, that is, $\Delta v/\Delta p$, becomes considerably steeper at low relative pressures.

Further experiment has shown that other gases show qualitatively similar behaviour. For example, at 22° C., CF_2Cl_2 (b.p. − 33° C. at Pretoria) gives a permeability in agreement with calculation; at 0° C., it behaves like sulphur dioxide at 22° C.; at − 25° C., it shows the same large increase of permeability as p_2 approaches the saturation vapour pressure, and a slow approach to a relatively small permeability when p_2 exceeds this. It is hoped to publish a fuller account of these data elsewhere.

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Daily Magnetic Variations near the Equators

The establishment of the observatory at Huancayo, Peru, near the magnetic equator, led to the discovery of daily magnetic variations, both solar and lunar, approximately twice as great as those previously found in other tropical regions. McNish[1] has sought to explain this anomaly by qualitatively modifying the Balfour Stewart – Schuster 'dynamo' theory to allow for the non-coincidence of the earth's magnetic and geographic axes. According to McNish, enhanced magnetic variations should occur in the areas between the magnetic and geographic equators. On the other hand, Egedal[2] and Chapman[3] have recently put forward data from tropical regions which appear to show that the distribution of the phenomenon is more complex than could be explained by McNish's suggestion.

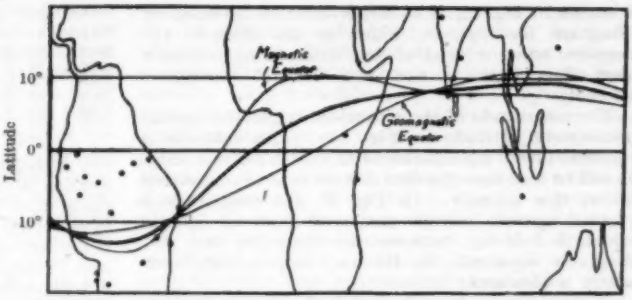

Fig. 1. Distribution of equatorial locations studied by Egedal and Chapman for anomalous magnetic variations. The heavy line is midway between the magnetic and geomagnetic equators

Now in 1908 Schuster[4] himself gave a quantitative account of the modifications introduced into the 'dynamo' theory by the non-coincidence of the earth's magnetic and geographic axes. It is easy to show that this produces symmetry of the variations about an equator which lies between the magnetic and true equators: the variations should show a shallow maximum at this 'magneto-dynamic' equator. McNish's qualitative arguments agree with Schuster's and lead to a small increase of the magnetic variations in the regions he specified: they cannot account for the very large increases found.

It is of interest to investigate whether the data examined by Egedal and Chapman show a symmetrical distribution of the anomaly about an equator. (The distribution of the sites examined by these authors

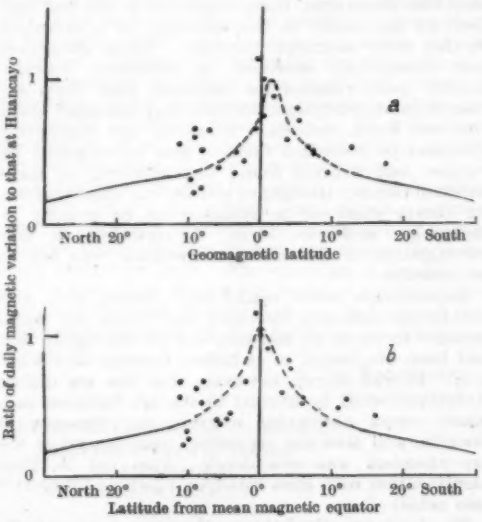

Fig. 2. Amplitude of daily magnetic variations plotted against (a) geomagnetic latitude, (b) latitude measured from a mean magnetic equator

is shown in Fig. 1.) The large variation revealed by Chapman for Uganda, which is not close to the *magnetic* equator (that of zero inclination), indicates that the latter is not the line of maximum anomaly.

The magnitude of the variations is plotted against *geomagnetic* latitude in Fig. 2*a*. (This latitude is measured from the equator of the earth's dipole axis.) It will be seen that the distribution is not symmetrical about this equator. In Fig. 2*b* the magnitude is plotted against latitude measured from an equator which is midway between the magnetic and geomagnetic equators. In this case approximate symmetry is obtained.

It would seem, therefore, that the observed anomalies require the existence in the ionosphere of a narrow region of high electric *conductivity* (about 15° of latitude wide) encircling the world approximately mid-way between the magnetic and geomagnetic equators.

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Emission Spectrum Attributed to Cadmium Fluoride

Emission bands attributed to cadmium fluoride by Asundi, Samuel and Zaki-Uddin[1] have been shown by Pearse and Gaydon[2] to be due to calcium fluoride. In their work, Pearse and Gaydon found six diffuse, band-like structures, three degraded to the red and three to the violet, in the spectrum of a cadmium arc fed with cadmium fluoride. These structures were tentatively ascribed to cadmium fluoride. Howell[3] gave reasons for believing that they are indeed due to cadmium fluoride, and arranged them into two band systems. However, the absorption spectrum of cadmium fluoride was investigated by Fowler[4] and nothing found corresponding to these emission bands; though, of course, it is quite possible for bands observed in emission to be missing in absorption and *vice versa*. Nevertheless, a new investigation of the emission spectrum was felt to be desirable.

Experiments were made with flames and arcs containing cadmium fluoride; but it was not found possible to excite in emission any of the bands that had been attributed to cadmium fluoride in absorption. It was found, however, that the six diffuse structures could be excited in the arc between cadmium metal electrodes without the presence of fluoride, and that the structures disappeared as the arc chamber was evacuated. This led to their identification with lines listed in Fowler's "Report"[5] (see table).

The lines are all of the combination type, strictly forbidden by elementary selection rules. Three of the lines, λλ 2961·48, 2862·30, 2818·73, which form

'CdF bands'			Cd lines		
λ(A)	I		λ(A)	I	
3005	(5)	R	3005·41	(1)	r
2961·5	(5)	V	2961·48	(4)	v
2908	(2)	R	2908·74	(1)	r
2904	(1)	R	2903·13	(1)	n
2862	(5)	V	2862·30	(2)	v
2819	(3)	V	2818·73	(1)	v

R = band degraded to red
V = band degraded to violet
r = line shaded to red
v = line shaded to violet
n = diffuse line

the multiplet $5s5p\ ^3P^0_{0,1,2} - 5s4f\ ^3F^0_{2,3,4}$ have been studied in detail by Ornstein and Burger[6], who conclude that the radiation is of the electrical dipole type forced by ionic electric fields. This conclusion is supported by the observations of Fukuda, Kayama and Uchida[7] on the excitation of all six of the lines in a high-current arc and also by Fujioka's study of their Stark effect[8]. The great asymmetry of the lines is brought about by the perturbation of the atomic energy-levels by the ionic fields forcing the radiation.

It is now well known that in certain circumstances bands may be mistaken for lines. This example shows that it is also necessary to beware of lines that may be mistaken for bands.

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Magnetic Polarizability of the Electron

The anomaly of the magnetic moment of the electron has been explained by Schwinger[1] as due to the interaction of the electron with the zero-point fluctuations of the radiation field. A particularly simple derivation has recently been given by Luttinger[2]. Luttinger considers the state of an electron in a constant magnetic field H such that its energy is exactly equal to mc^2, the energy of the orbital magnetic moment cancelling the energy of the spin magnetic moment. He then calculates the self-energy of the electron in this state due to the interaction with radiation, and expands this in powers of H. The term independent of H is divergent, being the well-known self-energy of the electron in the absence of any field, while the term proportional to H is finite and given by ($\hbar = c = 1$):

$$E = -\frac{e^2 H}{4\pi m}. \qquad (1)$$

This gives the radiative correction to the magnetic moment of the electron in agreement with experiments. It will be of interest to investigate also the terms of higher powers in H, for example, that proportional to H^2, which represents a magnetic polarizability of the electron. It is important to ascertain whether all the intrinsic properties of the electron are finite, except the self-energy and self-charge, which

are infinite. Since the electron has spin ½, field-independent moments other than a magnetic moment cannot exist; but polarizabilities and higher induced moments exist. To calculate the magnetic polarizability it is necessary only to carry the expansion in H one step further. This we have done, and it is found that this term is convergent for large values of the momentum of the virtual photons but diverges logarithmically for low values. This divergence, however, is due to an unpermissible expansion in powers of H, as can be seen by summing up the divergent contribution of this term with other contributions occurring in the higher powers of H. The result is a term involving $H^2 \log H$. Thus we find for the contributions to the self-energy due to the static and dynamic interactions with the virtual photons:

$$\left.\begin{aligned} E_{\text{static}} &= -\frac{e^4H^2}{90\pi m^3} + O(H^3) \\ E_{\text{dynamic}} &= -\frac{e^4H^2}{4\pi m^3} - \frac{2e^4H^2}{3\pi m^3}\log\frac{2eH}{m^2} + O(H^3) \end{aligned}\right\} \quad (2)$$

This result is finite, and it is quite easy to see that the terms proportional to higher powers of H are also finite. Owing to the logarithmic dependence on H, strictly speaking it is not correct to call (2) the 'magnetic polarizability', but this is of little importance. (2) is still smaller than (1) by a factor of the order $\frac{\mu_0 H}{mc^2}\log\frac{mc^2}{\mu_0 H}$ (where μ_0 is the Bohr magneton), which makes the polarizability for all practical purposes far too small to be observed at present.

I wish to express my thanks to Prof. Heitler for suggesting this investigation, and for valuable discussions.

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Analogue Calculating Machine for Functions of a Complex Variable

We have recently been concerned with a physical analogue to assist in dealing with functions of the complex variable, z, of the class:

$$f(z) = \frac{a_n z^n + a_{n-1} z^{n-1} + a_{n-2} z^{n-2} \ldots a_0}{b_m z^m + b_{m-1} z^{m-1} + b_{m-2} z^{m-2} \ldots b_0}$$

$$m \sim n = 1; \; a_n \; b_m \text{ real.} \quad (1)$$

This analogue device has many applications to electric network analysis and synthesis, and to other vibration problems; however, its capabilities would appear to be of sufficiently broad mathematical interest to warrant more general attention.

Such functions satisfy Laplace's equation $\nabla^2 f(z) = 0$, except at the singularities, and so may represent two-dimensional physical potential fields, for example, (*a*) an electrostatic field, (*b*) a stretched membrane, (*c*) a current-carrying conducting sheet, etc., with the singularities represented respectively by point charges, point displacements and point current sources. The system (*c*) has been found particularly suitable, using a shallow layer of electrolyte and by taking certain precautions to eliminate the boundary error[1], so that the electrolyte surface represents the infinite z-plane and includes an accessible 'infinity' point. A fine point electrode, carrying a constant current, placed at the point z_r, sets up a potential at any other point z proportional to $\log|(z-z_r)|$ and a potential gradient represented in both magnitude and direction by the conjugate of $(z-z_r)^{-1}$, both of which may be measured electrically. These properties form the basis of the analogue, which is applied in two different ways.

In the first application, the real, imaginary or complex zeros of either the numerator or denominator of (1) may be found, by exploring the potential gradient over the electrolyte surface set up by suitably placed electrodes, in order to locate the points of zero gradient. Furthermore, the case of complex coefficients, $a_n, \ldots b_n, \ldots$ etc., may also be dealt with[2].

Secondly, if $f(z)$ be factorized by this method, it may be represented in logarithmic form:

$$\log f(z) = \sum_{z=1}^{n} \log(z-z_z) - \sum_{p=1}^{m} \log(z-z_p), \quad (2)$$

by electrodes placed at the zeros z_z and poles z_p carrying currents proportional to their multiplicity (if multiple singularities are present). The potential over the electrolyte surface determines the modulus of $\log f(z)$, and, further, it may be shown that its argument is represented by the summation, along a line parallel to the imaginary axis, of the potential gradients (parallel to the real axis) between z and the real axis. This modulus and argument measurement, especially along the imaginary axis, has been reported previously.

Thirdly, with $\log f(z)$ thus represented, the residues at the simple poles of $f(z)$, which are in general complex, may be measured. The residue v_p at a pole z_p is the value of $f(z).(z-z_p)$ at $z = z_p$; this may be measured physically by removing the electrode at z_p and measuring $\log f(z)_{z=z_p}$ as explained above. A somewhat more complicated process enables the residues at double or triple poles to be determined. Knowledge of all the residues enables the inverse Laplace transform of $f(z)$ to be constructed.

Calculations can also be carried out on functions of other types; in general, any regular function satisfies Laplace's equation and is capable of similar physical interpretation, though not always by using point electrodes only. For example, a branch cut may be simulated by a strip, made of conducting or insulating material, depending upon the type of discontinuity possessed by the function, placed in the electrolyte.

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Measurement of Diversity

THE 'characteristic' defined by Yule[1] and the 'index of diversity' defined by Fisher[2] are two measures of the degree of concentration or diversity achieved when the individuals of a population are classified into groups. Both are defined as statistics to be calculated from sample data and not in terms of population constants. The index of diversity has so far been used chiefly with the logarithmic distribution. It cannot be used everywhere, as it does not always give values which are independent of sample size; it cannot do so, for example, when applied to an infinite population of individuals classified into a finite number of groups. Williams[3] has pointed out a relationship between the characteristic and the index of diversity when both are applied to a logarithmic distribution. The present purpose is to define and examine a measure of concentration in terms of population constants.

Consider an infinite population such that each individual belongs to one of Z groups, and let $\pi_1 \ldots \pi_Z$ ($\Sigma\pi = 1$) be the proportions of individuals in the various groups. Then λ defined as $\Sigma\pi^2$ is a measure of the concentration of the classification. It can take any value between $1/Z$ and 1, the former representing the smallest concentration or largest diversity possible with Z groups, and the latter complete concentration, all the individuals being in a single group. λ can be simply interpreted as the probability that two individuals chosen at random and independently from the population will be found to belong to the same group.

Now suppose a sample of N individuals to be chosen at random from a population of this kind, and let $n_1, n_2 \ldots n_Z$ ($\Sigma n = N$) be the numbers of individuals falling into the various groups. It is easily shown that $l = \dfrac{\Sigma n(n-1)}{N(N-1)}$ is an unbiased estimator of λ; this is almost obvious since $\frac{1}{2}N(N-1)$ is the number of pairs in the sample and $\frac{1}{2}\Sigma n(n-1)$ is the number of pairs drawn from the same group.

l is also an unbiased estimate of λ when the sample-size varies, provided no samples of size 0 or 1 are included and that the probability of the sample $(n_1, n_2 \ldots n_Z)$ splits into these two factors:

$$P(n_1, n_2 \ldots n_Z) = P(N)\,\frac{N!}{n_1!\,n_2!\ldots}\,(\pi_1)^{n_1}(\pi_2)^{n_2}\ldots,$$

where $P(N)$ gives the probability distribution of the sample size, $2 \leqslant N \leqslant \infty$. This is true in particular when samples are obtained by the 'fixed-exposure' method common in biological work, N having then a Poisson distribution adjusted for the absence of the first two terms.

If repeated samples of size N are drawn from the same population, the values of l obtained will be distributed about λ with variance

$$\frac{4N(N-1)(N-2)\,\Sigma\pi^3 + 2N(N-1)\,\Sigma\pi^2 - 2N(N-1)\,(2N-3)\,(\Sigma\pi^2)^2}{[N(N-1)]^2};$$

or, if N be very large, approximately

$$\frac{4}{N}\,[\Sigma\pi^3 - (\Sigma\pi^2)^2].$$

The third and fourth cumulants of the distribution of l have also been calculated exactly. They indicate that as N increases, the distribution tends to normality except when $\lambda = 1/Z$; in that case the distribution of lNZ tends to that of χ^2 with $Z-1$ degrees of freedom, but with its mean moved from $Z-1$ to N.

The characteristic defined by Yule[1] is, in the notation used above, $1{,}000\ \Sigma n(n-1)/N^2$, which differs from l, the sample estimator of λ, only in having N instead of $N-1$ in the denominator and in the scale factor of 1,000.

Now let us see what value λ takes for a population containing Z groups the frequencies of which are $\pi_i = w_i/\Sigma w$, where the w_i are chosen at random and independently from the Type III distribution

$$dF = \frac{1}{(k-1)!}\,e^{-w}\,w^{k-1}\,dw, \qquad 0 \leqslant w \leqslant \infty.$$

This may be called a 'negative binomial population', since samples drawn from it by the 'fixed exposure' method will obey the negative binomial distribution. The value of λ appropriate to it is obtained by averaging $\Sigma w_i^2/(\Sigma w_i)^2$ over all sets $(w_1, w_2 \ldots w_Z)$ which can be drawn from the population of values of w. Thus

$$\lambda = \int_0^\infty \cdots \int_0^\infty \left[\frac{1}{(k-1)!}\right]^Z e^{-\Sigma w}\,[w_1 \ldots w_Z]^{k-1}\,\frac{\Sigma w_i^2}{(\Sigma w_i)^2}\,dw_1 \ldots dw_Z = \frac{k+1}{Zk+1}.$$

The Poisson distribution is the special case of the negative binomial distribution in which k tends to infinity. Under this condition, $\lambda = 1/Z$. This is as we would expect, since the Poisson distribution arises from a population in which all groups are equally represented, and so the probability that two individuals chosen at random will be found to belong to the same group must be $1/Z$.

The other extreme case of the negative binomial is the logarithmic population, which is obtained by letting Z tend to infinity and k tend to zero simultaneously so that the product Zk remains finite and tends to a quantity called α. (This is not quite the same derivation as that used by Fisher[2], but the quantity α is the same as his index of diversity.) The value obtained for λ under this limiting process is $1/(\alpha+1)$.

It will be noticed that this last value is not consistent with the equation given by Williams[3], namely, that Yule's characteristic had the value $1{,}000/\alpha$ when applied to the logarithmic distribution. His result was obtained by applying Yule's formula to a series of expected values, whereas the present procedure is equivalent to applying the formula first and then averaging the result. Some support for the new equation is found by considering the ranges of the variables concerned. Since the characteristic cannot exceed 1,000, the earlier equation would deny to α all values less than 1; but the present one allows it the range $0 \leqslant \alpha \leqslant \infty$, while $1 \geqslant \lambda \geqslant 0$.

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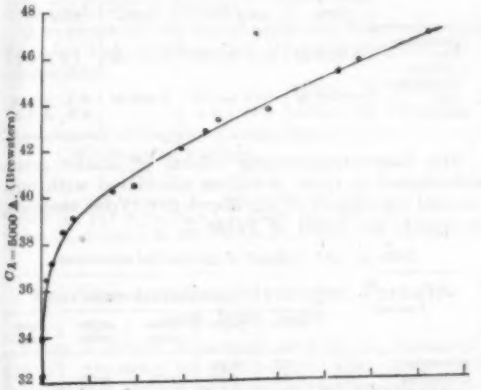
Photo-elastic Creep in 'Catalin 800' and *CR* 39

During the course of an investigation on the variation with wave-length λ of the stress-optic coefficient C_λ of 'Catalin 800' (a glass-clear phenol-formaldehyde resin) and of *CR* 39 (a condensed allyl ester), it has been found that C_λ depends upon the time allowed to elapse between the application of the load and the measurement of the resultant birefringence, the effect being due to the so-called photo-elastic creep in the loaded specimens. The two specimens, one of 'Catalin' and the other of *CR* 39, were both strained by a tensile force applied by a simple loading machine working on the lever principle, and the stress-optic coefficients were determined by the modified form of Filon's method[1], using a spectrograph instead of the usual spectrometer.



O—O—, Experimental points; curve computed from $C_\lambda = c_0' + c_1'\{1 - \exp(-kt^{1/3})\} + c_2't$

From the spectrogram formed by plane-polarized parallel light which has passed through a narrow limited section of the strained specimen, C_λ for a given wave-length can be deduced. From a series of such spectrograms, taken at intervals of time, t, after loading, values of C_λ for $\lambda = 5000$ A. were calculated, and plotted against t. Equations were fitted to the curves.

For 'Catalin' the results agree with those of Mylonas[2], the relation between C_λ and t being

$$C_\lambda = c_0 + c_1 t^{0.2}, \qquad (1)$$

where c_0 and c_1 are constants. The maximum duration of the test was 24 hours, though Mylonas, who originally suggested (1), used tests of duration less than one hour. For periods of continuous loading up to one hour, the experimental results agree with (1) to within 1 per cent, and for periods of 24 hours to within 5 per cent. c_0 and c_1 vary considerably from test to test, appearing to depend upon the history of the specimen. (A similar effect has been observed by previous investigators but for other materials.) Since the same value of load was used throughout, the dependence, if any, of c_0 and c_1 on the stress could not be ascertained.

For *CR* 39 more detailed results were obtained, but, as for 'Catalin', for one value of load only. The 'creep'-rate was not as rapid as for 'Catalin'. For short-period loadings, C_λ and t are related exponentially, but for long-period loading (over a range of 400 hr.) a better fit to the experimental results is given by

$$C_\lambda = c_0' + c_1'[1 - \exp(-kt^{1/3})] + c_2't \qquad (2a)$$

for $\lambda = 5000$ A., where c_0', c_1' and c_2' are constants and t is in hours; k is numerically of the order of 0·32. After 450 hours, the observed values of C_λ were less than those given by (2*a*), and it is probable that the linear term $c_2't$ should be replaced then by another exponential term. For short-period loading it is clear that (2*a*) reduces to

$$C_\lambda = c_0' + c_1'[1 - \exp(-kt^{1/3})], \qquad (2b)$$

since c_0', c_1' and c_2' are of the order of 30 and 9 Brewsters, and 0·015 Brewsters per hour respectively. It is interesting to note that a relationship of the form of (2*b*) was originally suggested by Pierce[3] in connexion with the variation of the torsion of a cotton thread with time.

In the past, investigators have found a similarity between optical and mechanical 'creep' behaviours in various materials. A brief check of the mechanical 'creep' properties of 'Catalin' or *CR* 39, by measuring the deflexions of beams of the two materials when subjected to a constant bending moment, was made. Relations approximately analogous to those of (1) and (2*b*) were obtained.

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Amino-Acid Composition of Salmine

A detailed chemical analysis of the amino-acid composition of salmine (from a commercial source) was presented by Block and Bolling[1], who used chemical and microbiological techniques. The amino-acids found were arginine, alanine, *iso*leucine, proline, serine and valine. Tristram[2] confirmed the presence of these, and in addition demonstrated that glycine was also a constituent.

In the course of other work, analyses have been made in this Laboratory of hydrolysed salmine (commercial) by partition chromatography on paper. The 'ascending' modification of the original method was used[3]. We thought it of interest to report that our results confirmed those of Tristram. No other amino-acids were detected using one- or two-dimensional chromatograms when phenol with ammonia, collidine–lutidine mixture 1 : 1 (v/v), or *n*-butanol–acetic acid mixture 4 : 1 (v/v), were used as solvents.

An estimate of the proportions of amino-acids present has been made by the spot-dilution technique[4]. The results are presented in the accompanying table.

	Amino-acid per 100 gm. salmine		
Amino-acid	Authors	Tristram	Block
Arginine	87·5	85·2	88·4
Alanine	0·6	1·10	3·6
Glycine	3·6	2·94	—
*iso*Leucine	1·8	1·61	1·5
Proline	5·0	5·8	7·9
Serine	5·6	9·1	7·0
Valine	3·8	3·1	4·1

The proportions found were in fair agreement with those of the earlier workers; but appreciably lower values were obtained for the amounts of alanine and serine. The hydrolysis was carried out by heating the salmine in a sealed tube with 5*N* hydrochloric acid for 40 hr. at 90° C. The low values observed in the case of alanine and serine do not appear to be attributable either to incomplete hydrolysis or to destruction during digestion, because (*a*) the results were not altered by considerably longer periods of hydrolysis, and (*b*) chromatograms of a mixture of the seven amino-acids before and after treatment, under the conditions of the hydrolysis, showed no detectable destruction of any component.

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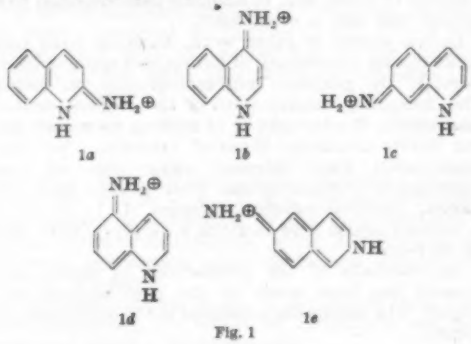
Base-Strengthening Effect of Resonant Amino Groups in some Heterocyclic Bases

It was shown by Albert and Goldacre[1] that an amino group substituted in a 'resonant position' of a six-membered aromatic heterocyclic base results in a compound of enhanced basic strength. This is attributed to the replacement of a dipolar resonant form by a more stable homopolar resonant form.

The ionic quinonoidal structures discussed by Albert and Goldacre[1] fall into four groups: (1) an *ortho*-quinonoid structure, as represented by 2-amino quinoline (Fig. 1*a*); (2) a *para*-quinonoid structure, as represented by 4-amino quinoline (Fig. 1*b*); (3) an *ortho-para*-quinonoid structure, as represented by 7-amino quinoline (Fig. 1*c*); (4) an *ortho-ortho*-quinonoid structure, as represented by 5-amino quinoline (Fig. 1*d*). A fifth possibility, that of a *para-para*-quinonoid structure, was not considered by them. The simplest example of this type would be 6-amino *iso*quinoline (Fig. 1*e*).



1*a* 1*b* 1*c* 1*d* 1*e*

Fig. 1

It seemed of interest to determine the base-strengthening effect (ΔpK_A) of such a *para-para*-quinonoid structure, in order that a comparison of the relative stabilities of the above five structures can be made. For this purpose 2-amino benzcinnoline (Fig. 2) was chosen, 6-amino *iso*quinoline being unavailable.

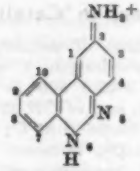


Fig. 2

The pK_A of benzcinnoline and of its 2-amino derivative was determined, in water by the colorimetric method described by Albert and Goldacre[1], and in 50 per cent ethanol by potentiometric titration (glass-electrode). The results are expressed in Table 1.

Table 1

	Water		50% ethanol	
	Conc.	pK_A (20°)	Conc.	pK_A (20°)
Benzcinnoline	0·0002 *M*	2·20 ± 0·05	0·05 *M*	1·6 ± 0·2
2-Amino benzcinnoline	0·0002 *M*	6·68 ± 0·05 4·48 ± 0·1	0·006 *M*	6·23 ± 0·05 4·6 ± 0·2
ΔpK_A				

The base-strengthening effects of amino groups substituted in those positions associated with quinonoidal resonances of the above five types, measured in water, are listed in Table 2.

Table 2. ΔpK_A effects* of quinonoidal resonances

Nucleus	Quinonoidal structure				
	ortho-	*para-*	*ortho-para-*	*ortho-ortho-*	*para-para-*
Pyridine	1·63	3·94	—	—	—
Quinoline	2·40	4·23	1·71	0·52	—
*iso*Quinoline	2·29	—			
Acridine	—	4·39	2·44	0·44	—
3 : 4-Benzacridine	—		2·72		—
Pyridazine	2·86		—	—	—
Pyrimidine	2·24	4·41	—	—	—
Pyrazine	2·54	—	—	—	—
Cinnoline	—	4·14			
Phthalazine	3·13	—		—	
Quinazoline	0·92†	2·22†			
Quinoxaline	3·16	—			—
3 : 4-Benzcinnoline	—	—			4·48

* Values (water) calculated from Albert, Goldacre and Phillips[2].
† The anomalous values for quinazoline will be discussed in a future note by one of us (*J. N. P.*).

From Table 2 it can be seen that the ΔpK_A associated with any particular quinonoidal structure is reasonably constant for several heterocyclic nuclei. (It is interesting to note, in view of the great differences in water solubility of the compounds in Table 2, that solvation seems to play only a minor part.) The constancy of pK_A suggests that the resonance energy of such a structure is the predominant factor in determining the basic strength. The relative stability of the five structures is seen to be

para- and *para-para-* > *ortho-* and *ortho-para-* > *ortho-ortho-*.

Since the presence of fused benzene rings does not appreciably influence the ΔpK_A, then from the above postulate that a *para-para*-quinonoid is of the same order of stability as a *para*-quinonoid structure, it would follow that a *para*-quinonoid and an isolated Kekulé structure are of approximate total energy equivalence. The fact that the *ortho-* and *ortho-para*-quinonoid types show the same order of stability supports this conclusion. It can similarly be reasoned that an *ortho*-quinonoid structure is of greater total

energy (less stability) than an isolated Kekulé structure.

The figures in Table 2 enable one to predict approximate pK_A values (in water) for bases giving rise to ionic forms of the above five types. ΔpK_A values (averaged from Table 2) would be *ortho* = + 2·5, *para* = + 4·2, *ortho-para* = + 2·3, *ortho-ortho* = + 0·5, *para-para* = + 4·5.

In this way, from the pK_A values of *iso*quinoline (5·33, water), phthalazine (3·47, water) and phenanthridine (3·30, 50 per cent ethanol), the pK_A values of 6-amino *iso*quinoline, 6-amino phthalazine and 6-amino phenanthridine may be predicted to be 9·8 (water), 8·0 (water) and 7·9 (50 per cent ethanol; see Table 1 for ΔpK_A), respectively. These three bases (*para-para*-quinonoid type) would be the strongest mono-amino derivatives in their series, since in each case no amino derivative of the *para*-quinonoid type is possible.

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Reaction between Hydrogen Peroxide and Iron Salts

FROM a recent discussion with J. H. Baxendale and P. George, we understand that they have from kinetic studies proposed a reaction scheme for the mechanism of the evolution of oxygen from hydrogen peroxide and ferrous ions [see p. 692 of this issue of *Nature*]. We have also obtained experimental evidence from the studies of the consumption ratios which lead to conclusions similar to theirs and which are discussed in the following.

The reaction between hydrogen peroxide and ferrous salts has been studied by Haber and Weiss[1] and certain aspects of it more recently again by Baxendale, Evans and Park[2]. We have now studied this reaction in its dependence on *p*H, and we have investigated the role of the ferric ions in the hydrogen peroxide ferrous-ion reaction.

We have used a flow apparatus built on similar lines to those suggested by Schmid[3], to bring about a very rapid mixing of the component solutions and thus to ensure well-defined initial concentrations of the reactants. So far, only consumption ratios ($-\Delta(H_2O_2)/-\Delta(Fe^{II})$) have been measured.

In order to study the effect of ferric ions, we have investigated the reaction (at different *p*H) in the presence of (i) fluoride, (ii) pyrophosphate ions, both of which are known to form stable complexes with ferric ions, and we have convinced ourselves that these complexes are not active as catalysts. We have found that fluoride and pyrophosphate ions both decrease the consumption ratios.

It is of importance to note that the hydrolysis products of ferric ions (which are formed if the reaction is carried out at sufficiently high *p*H) are themselves also practically inactive as catalysts during time intervals which are relevant for the relatively fast reaction between ferrous ions and hydrogen peroxide.

Conversely, we have been able to show that addition of ferric salts (over and above that formed by the oxidation of the ferrous salt) increases the consumption ratios. This clearly indicates that ferric ions are involved in the ferrous ion catalysis, which, however, must not be confused with the well-known relatively slow catalytic decomposition of hydrogen peroxide by ferric salt alone.

It seems that all this can be explained by a slight modification of the original scheme of Haber and Weiss by introducing into the 'ferrous ion catalysis' one of the reactions (reaction (14) of ref. 1) which has been considered previously in connexion with the 'ferric ion catalysis'.

The decrease of the consumption ratios with decreasing *p*H suggests further that it is the anion, O_2^-, rather than the undissociated HO_2 which enters into the reaction, the two being connected by the equilibrium $HO_2 \rightleftharpoons H^+ + O_2^-$.

Thus in addition to the original equations:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + OH \quad \ldots (1)$$

$$H_2O_2 + OH \rightarrow H_2O + HO_2 \quad \ldots (2)$$

$$H_2O_2 + HO_2 \rightarrow O_2 + H_2O + OH \quad \ldots (3)$$

$$Fe^{2+} + OH \rightarrow Fe^{3+} + OH^- \quad \ldots (4)$$

with a possible additional chain-breaking by the interaction of two radicals, for example:

$$HO_2 + OH \rightarrow O_2 + H_2O, \quad \ldots (5)$$

one has the oxygen-producing reaction:

$$Fe^{3+} + O_2^- \rightarrow Fe^{2+} + O_2; \quad \ldots (6)$$

which reaction, in the presence of ferric ions, largely replaces reaction (3); this, on the other hand, is of fundamental importance in the photochemical decomposition[4] and in the decomposition of hydrogen peroxide by ionizing radiations[5].

Reaction (6) is also of great importance in the aerobic oxidation of ferrous ions, as discussed previously[6].

If, on the other hand, one starts with ferric ions only, the initial reaction is represented by the well-known process[1]:

$$Fe^{3+} + HO_2^- \rightleftarrows Fe^{2+} + HO_2 \quad \ldots (7)$$

which, in conjunction with the oxygen-producing reaction (6) and followed by the re-oxidation of the ferrous ions according to reactions (1) and (4), gives a sufficiently complete picture of the 'ferric ion catalysis' of hydrogen peroxide as discussed in the earlier paper[1]. However, in general one has to include also the reverse process of reaction (7) and the chain reactions (2) and (3) as discussed previously.

Thus the only difference compared with the previous scheme is that reaction (6) preponderates over reaction (3) if ferric ions are present.

A full account with all the experimental details will be published elsewhere.

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REACTIONS OF FERROUS AND FERRIC IONS WITH HYDROGEN PEROXIDE

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IN the elucidation of the mechanism of the reactions between hydrogen peroxide and ferrous and ferric ions, a considerable advance was made by Haber and Weiss[1], who suggested that the highly reactive intermediates which have been shown to be present were the radicals HO· and HO_2. Their mechanisms, recently revised by Weiss[2], are as follows:

Fe^{2+} reaction

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + HO\cdot$$
$$H_2O_2 + HO\cdot \rightarrow H_2O + HO_2$$
$$H_2O_2 + HO_2 \rightarrow O_2 + H_2O + HO\cdot$$
$$Fe^{2+} + HO_2 \rightarrow Fe^{3+} + HO_2^-$$
$$Fe^{2+} + HO\cdot \rightarrow Fe^{3+} + OH^-$$

Fe^{3+} reaction

$$H_2O_2 \rightarrow H^+ + HO_2^-$$
$$Fe^{3+} + HO_2^- \rightarrow Fe^{2+} + HO_2$$
$$H_2O_2 + HO_2 \rightarrow O_2 + H_2O + HO\cdot$$
$$Fe^{2+} + HO\cdot \rightarrow Fe^{3+} + OH^-$$
$$OH^- + H^+ \rightarrow H_2O$$

The reaction with the ferrous ion is seen to involve chains with HO· and HO_2 as carriers; the ferric ion reaction consists of a sequence of radical reactions. In both cases oxygen is evolved by HO_2 reacting with hydrogen peroxide.

We have made an extensive experimental investigation which has revealed several new facts incompatible with the above scheme for the ferrous ion reaction. We conclude that the reaction producing oxygen is not that of HO_2 with hydrogen peroxide, but HO_2 or O_2^- with the ferric ion, and we propose a chain reaction involving HO_2, HO· and Fe^{2+} as carriers. The same chain mechanism will interpret satisfactorily both the ferrous and the ferric reactions.

The following is a summary of our observations on the ferrous ion reaction.

Ferrous Ion Reaction

It has previously been found that with low H_2O_2/Fe^{2+} ratios and in acid solutions the reaction is second order and the overall stoichiometry is $2Fe^{2+} \equiv H_2O_2$. When an excess of a polymerizable vinyl compound is present, the reaction is still second order in ferrous ion and hydrogen peroxide, but the stoichiometry changes to $Fe^{2+} \equiv H_2O_2$. Under these conditions polymerization occurs and the polymer has terminal hydroxyl groups. These observations are good evidence that the following reactions occur[3]:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + HO\cdot \quad (o)$$
$$Fe^{2+} + HO\cdot \rightarrow Fe^{3+} + OH^- \quad (1)$$
$$M + HO\cdot \rightarrow HOM\cdot \rightarrow \text{polymer}$$

In the absence of substrate the rate equation is

$$-d[Fe^{2+}]/dt = 2k_o[Fe^{2+}][H_2O_2].$$

However, although at low H_2O_2/Fe^{2+} ratios monomers are polymerized, leuco dyestuffs oxidized to the dye, and certain dyes destructively oxidized, thus confirming the presence of the radical HO, we have found that at the same concentrations of ferrous ion and substrate these reactions do not occur with high concentrations of hydrogen peroxide.

It is clear that under these conditions another competitor for HO· is present, and the observations can be explained if HO· reacts with hydrogen peroxide to give HO_2. The HO_2 radical thus formed is apparently unable to open the double bond of a vinyl compound or to oxidize the other substrates.

With high H_2O_2/Fe^{2+} ratios, oxygen is evolved on the addition of ferrous ion to hydrogen peroxide, which means that the stoichiometry is no longer $2Fe^{2+} \equiv H_2O_2$ and other reactions enter in addition to (*o*) and (1) above. The following results obtained in perchloric acid solutions from *p*H 1 to *p*H 3 enable the mechanism of reaction in this *p*H range to be deduced.

(1) *Ferrous Ion Kinetics.* With concentrations of ferrous ion of approximately 10^{-5} *M* and hydrogen peroxide less than 10^{-3} *M*, $d[Fe^{2+}]/dt$ can be measured by determining the concentration of ferrous ion, $[Fe^{2+}]$, colorimetrically with dipyridyl. Peroxide can be estimated by adding to excess acid Fe^{2+} or as pertitanic acid. Provided $2[Fe^{2+}] > [H_2O_2]$ initially, the reaction is second order throughout with $2Fe^{2+} \equiv H_2O_2$. This holds up to *p*H 3. At high H_2O_2/Fe^{2+} ratios the reaction initially follows the normal second-order course; but the 'rate constant' $k_{obs.}$ decreases as the reaction proceeds. This effect is shown in Fig. 1, curves (*a*) and (*b*), where the results are plotted as for a second-order reaction with hydrogen peroxide in great excess. Values of $k_{obs.}$ which are less than half that of the overall normal constant $2k_o$ are obtained. For a given

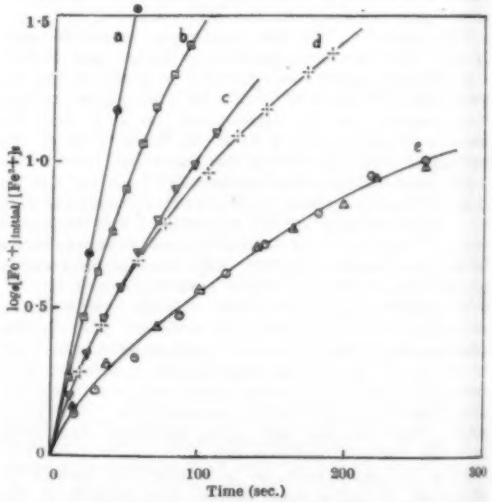

Fig. 1. Course of $Fe^{2+} + H_2O_2$ reaction with initial concentrations $1{\cdot}4 \times 10^{-5}$ Fe^{2+} and $29{\cdot}5 \times 10^{-4}$ *M* H_2O_2 at 25° C., and *p*H 2·65 except in (*a*). In no case is more than 10 per cent of the hydrogen peroxide used over the time interval shown. (*a*) *N*/2 $HClO_4$; (*b*) no additions; (*c*) initially $4{\cdot}6 \times 10^{-5}$ *M* Fe^{2+}; (*d*) initially $1{\cdot}4 \times 10^{-5}$ *M* Cu^{2+}; (*e*) initially $2{\cdot}4 \times 10^{-4}$ (△) and $1{\cdot}2 \times 10^{-3}$ *M* Fe^{2+} (○)

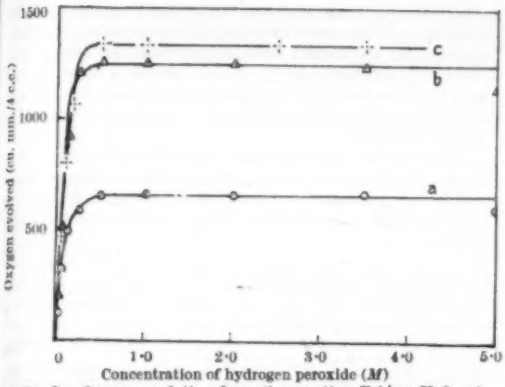

Fig. 2. Oxygen evolution from the reaction $Fe^{2+} + H_2O_2$ at various concentrations of hydrogen peroxide. (*a*) *p*H 1·5; (*b*) *p*H 1·8; (*c*) *p*H 1·5 with 4×10^{-4} *M* Fe^{2+} initially. Initial Fe^{2+}, 4×10^{-5} *M* in each case

initial concentration of ferrous ion, these deviations from second order increase with hydrogen peroxide concentration until eventually the effect of increasing the peroxide reaches a limit. This is paralleled by the dependence on the peroxide concentration of the total amount of oxygen evolved as the ferrous ions are oxidized to ferric ions given in (2) below.

Moreover, the course of a reaction from any time *t* onwards can be reproduced *ab initio* only with solutions of the same concentrations of hydrogen peroxide, ferrous ions and *also* ferric ions as at time *t*, but *not* with solutions containing the same concentrations of peroxide and ferrous ions alone.

(2) *Oxygen Evolution.* The total amount of oxygen evolved as the ferrous ion is oxidized to the ferric is easily determined from an oxygen evolution – time plot by extrapolating the linear portion, due to the subsequent catalysis of ferric ions back to zero time[4]. Above a certain H_2O_2/Fe^{2+} ratio it is found to be independent of the concentration of hydrogen peroxide and varies approximately inversely with the concentration of hydrogen ions over the range *p*H 1–2 (Fig. 2 (*a*) and (*b*)).

(3) *Effect of Ferric or Cupric Ions.* If ferric ions are added to a reaction mixture, the total oxygen evolved as ferrous ions are oxidized is greatly increased, and $k_{obs.}$ is less than 2 k_0 even at the beginning of a reaction. The same effect is observed with cupric ions, with the striking difference that the cupric ion is more efficient than the ferric (see Figs. 1 (*c*) and (*d*) and 2 (*c*)). This effect at first increases with increase of ferric or cupric ion; but we find that for any given concentration of hydrogen peroxide and ferrous ion, the evolution of oxygen and deviations from second-order reaction are unaffected by further additions of ferric or cupric ions beyond a certain amount (see Fig. 1 (*e*)). In addition, at H_2O_2/Fe^{2+} ratios where the evolution of oxygen is normally independent of the concentration of hydrogen peroxide, it increases with the latter when these limiting amounts of ferric or cupric ions are present. Similarly, the limiting deviations from second order at high concentrations of hydrogen peroxide described in (1) above are no longer observed at sufficiently high concentrations of ferric and cupric ions.

(4) *Effect of Fluoride Ions.* In the presence of fluoride ions, the total evolution of oxygen is decreased, and a system which would have shown deviations from second-order kinetics no longer does so.

From the observations described in (1)–(4), we conclude that: (*a*) The oxygen is *not* evolved as the result of a reaction between HO_2 and hydrogen peroxide, with a terminating reaction between ferrous ions and HO· or HO_2. In these cases, it would always increase with the concentration of hydrogen peroxide, whereas we find it reaches a limiting value.

(*b*) The oxygen is evolved in a reaction involving ferric (or cupric) ions. This is probable because of the increase obtained by addition of these ions, and the decrease when ferric ions are removed by fluoride.

(*c*) Ferrous ions are regenerated by the oxygen evolution reaction. This is probable because we have found that at high H_2O_2/Fe^{2+} ratios, $k_{obs.}$ can be much less than k_0, the value it would have if all reactions involving ferrous ions, other than the primary step (*o*) above, were eliminated (see ref. 3). Hence ferrous ions must be regenerated during the reaction. Further, $k_{obs.}$ is even smaller, and thus ferrous ions are regenerated more rapidly when ferric (or cupric) ions are present initially, that is, under the conditions for increased oxygen evolution. The most probable reaction to account for these observations is one between Fe^{3+} or Cu^{2+} and HO_2.

(*d*) Another reaction which removes ferrous ions occurs in addition to reaction (1) above. This is required because the qualitative experiments with substrates suggest that most HO· reacts with hydrogen peroxide at high H_2O_2/Fe^{2+} ratios, and hence $Fe^{2+} + HO\cdot$ is no longer a significant reaction. But in spite of this, the ferrous ions are still removed initially at a rate which corresponds to that at low H_2O_2/Fe^{2+} ratios, that is, $k_{obs.}$ is always initially equal to 2 k_0 in the absence of added ferric ions. The kinetics can be accounted for if the additional reaction is between ferrous ions and HO_2.

Reaction Scheme. From these considerations we propose the following reaction scheme:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + HO\cdot \quad k_0 \quad (o)$$
$$Fe^{2+} + HO\cdot \rightarrow Fe^{3+} + OH^- \quad k_1 \quad (1)$$
$$H_2O_2 + HO\cdot \rightarrow H_2O + HO_2 \quad k_2 \quad (2)$$
$$Fe^{2+} + HO_2 \rightarrow Fe^{3+} + HO_2^- \quad k_3 \quad (3)$$
$$Fe^{2+} + HO_2 \rightarrow Fe^{3+} + O_2 + H^+ \quad k_4 \quad (4)$$

At very low H_2O_2/Fe^{2+} ratios, only steps (*o*) and (1) occur, the reaction is second order and the evolution of oxygen is zero. As the ratio increases, the course of reaction is determined by competition for HO· in (1) and (2); hence the evolution of oxygen and deviations from second-order kinetics increase with the concentration of hydrogen peroxide. At high H_2O_2/Fe^{2+} ratios, the competition for HO_2 in (3) and (4) predominates, and since these do not involve hydrogen peroxide, the oxygen evolved and the kinetic deviations become independent of the concentration of hydrogen peroxide. The effect produced by cupric ions can be explained if they react more readily than ferric ions in (4), and we have

$$Cu^{2+} + HO_2 \rightarrow Cu^+ + O_2 + H^+ \quad (5)$$
$$Cu^+ + Fe^{3+} \rightarrow Cu^{2+} + Fe^{2+} \quad \text{(very fast)}.$$

These two reactions amount to a catalysis of reaction (4). The limiting conditions attained in the presence of ferric or cupric ions are seen to arise when (4) or (5) predominate to such an extent that HO_2 termination in (3) is no longer significant compared with HO· termination in (1). Under these conditions, the total oxygen evolved and $k_{obs.}$ should again be

dependent on the concentration of hydrogen peroxide as observed.

The kinetics of the reaction and the amount of oxygen evolved are found to agree with the expressions which can be deduced from the above mechanism, and, from the kinetic analysis, values for k_4/k_2 and k_1/k_2 can be obtained. These will be discussed in a later publication. We find that k_1/k_2 is independent of pH, whereas $k_4/k_2 = \frac{K}{[H^+] + K_1}$ over the range examined. K_1 is found to be about 6×10^{-3}, which corresponds closely to the equilibrium constant of[5]

$$Fe^{3+} + H_2O \rightleftarrows FeOH^{2+} + H^+.$$

The variation of k_4/k_2 with the concentration of hydrogen ions can be accounted for if the reactants in (3) and (4) are

(i) $Fe^{2+} + HO_2$, and $Fe^{3+} + O_2^-$
or (ii) $Fe^{2+} + HO_2$, and $FeOH^{2+} + HO_2$
or (iii) $Fe^{2+} + O_2^-$, and $FeOH^{2+} + O_2^-$.

A detailed kinetic analysis shows that only the reactions in (i) occur.

Ferric Ion Reaction

The catalytic decomposition of hydrogen peroxide by ferric salts has been found to be first order both with regard to hydrogen peroxide and ferric ions, and to vary inversely as the concentration of hydrogen ions[2]. This kinetic form can be obtained if the initial reaction is

$$Fe^{3+} + HO_2^- \rightarrow Fe^{2+} + HO_2 \ldots . ki, \qquad (i)$$

and is followed by reactions (*o*), (2), (3) and (4) in the ferrous ion scheme above. The exclusion of (1) is justified since these experiments have usually been done at high H_2O_2/Fe^{3+} ratios. This mechanism is to be preferred to that proposed by Weiss[3] because it retains reactions which are necessary to explain the ferrous ion reaction, and which cannot be ignored in the ferric ion reaction. An important feature of the above scheme is that it is a chain reaction rather than a sequence of radical reactions as proposed by Weiss. Preliminary calculations using the constants derived from the study of the ferrous ion reaction indicate a chain-length of about 10^3.

A recent investigation of the ferric ion reaction by Andersen[6] shows that at *low* H_2O_2/Fe^{3+} ratios the reaction is no longer first order with regard to hydrogen peroxide, but somewhat higher. The data of Simon *et al.* show similar features[7]. The higher order can be understood if at these low H_2O_2/Fe^{3+} ratios reaction (1) becomes significant, for if (1) *completely* replaces (3) as a chain termination reaction, the decomposition-rate is given by

$$-d[H_2O_2]/dt = k\,[Fe^{3+}]^{1/2}\,[H_2O_2]^{3/2}. \qquad (6)$$

The well-established promotion by cupric ions of the ferric ion catalysed decomposition of hydrogen peroxide, which has been examined in some detail by Bohnson and Robertson[8], gives further support. They observed a limiting promotion effect by cupric ions which is similar to that described above in the ferrous ion reaction and can be explained in the same way, namely, by the predominance of reaction (5) over (3), causing all chain termination to occur by reaction (1), thus making the overall reaction independent of the concentration of cupric ions. Furthermore, the predicted rate expression in these conditions is the same as (6) above, and this is supported by the data available in that they show a dependence of the rate on the square root of the concentration of ferric ions, $[Fe^{3+}]^{1/2}$.

These ferric ion reactions are being investigated in more detail to check the above kinetic expressions.

We are indebted to Prof. M. G. Evans for advice and helpful discussions during the course of this work.

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THE RARE ISOTOPE OF HELIUM, He^3; A KEY TO THE STRANGE PROPERTIES OF ORDINARY LIQUID HELIUM, He^4

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A VERY interesting experiment with the rare helium isotope helium-3 has recently been made by D. W. Osborne, B. Weinstock and B. M. Abraham, of the Argonne National Laboratory in Chicago[1]. This experiment is crucial, as it may decide the correctness of a theory devised eleven years ago[2] to explain the peculiar properties of the fluid into which ordinary liquid helium turns when cooled below the temperature of 2·19° abs. (about two degrees below its normal boiling point of 4·2° abs.).

Above 2·19° abs., liquid helium behaves very much like any other liquid; it shows ordinary viscous flow, normal heat conductivity, etc. At 2·19° abs. it undergoes a strange change of state; its entropy, that is, its degree of thermal disorder, very rapidly decreases within a small temperature-range with a discontinuity of the specific heat at 2·19° abs. (λ-point). However, instead of solidifying as any other liquid would do if cooled to a sufficiently low temperature, liquid helium turns, below 2·19° abs., into a very peculiar kind of fluid, which has characteristically been called 'superfluid'. It no longer has an ordinary viscosity, it leaks through the finest cracks which were practically tight for helium, liquid or gaseous, above 2·19°. It shows a particular transfer of heat with a facility incomparably better than any other substance. One speaks of 'heat-superconductivity'. In addition, there are many other utterly strange features by which liquid helium below 2·19° abs., called 'liquid helium II', is distinguished from all other known liquids.

The theory proposed by me in 1938 tried to relate the unique properties of liquid helium II to those of what one calls an 'ideal Bose–Einstein gas'. In 1924, Einstein[3], generalizing ideas of the Indian physicist Bose, had developed a very strange concept of a gas consisting of identical molecules, which are assumed

to be in a very radical sense indistinguishable from each other. He conceived that it should not only be impossible to distinguish a case (I) where molecule A is here and molecule B is there from another case (II) where molecule B is here and molecule A is there, but that one should not even count these two indistinguishable cases, I and II, as two separate cases; rather they should be considered as *one single case* only. Einstein remarked that this kind of taking away the last vestige of individuality from the molecules of a species would lead to a curious "condensation phenomenon". Even disregarding the forces between the molecules, one would obtain a peculiar change of state of aggregation at a well-defined temperature; the molecules would 'condense' in a certain, though not in a crystallized, state. Einstein himself did not give a detailed proof, and his strange remark received little attention at that time. Most people considered it as a kind of oddity which had, at best, an academic interest, since at the extremely low temperature in question there are no gases, all substances being frozen or at least condensed. In addition, doubt was cast on the mathematical correctness of Einstein's remark. Thus the matter was dealt with in a sense as if there is no 'Bose–Einstein condensation'.

When the strange properties of superfluid helium became known, during 1937–38, I remembered the remarks of Einstein on the 'Bose–Einstein condensation', and worked out the theory in more detail. In the meantime, from quite another source, namely, from spectroscopic observations with helium molecules, direct evidence has been found which could only be interpreted by assuming that permutations of helium atoms are, indeed, to be counted in the way suggested by Einstein. Thus it happened that only at that time it was ascertained that an ideal Bose–Einstein gas would actually show a break in the specific heat, c_v. In particular, for molecules of the molecular weight and the density of liquid helium, this break would occur at a temperature of 3·09° abs., very close indeed to the 2·19° abs. of the transition temperature of liquid helium. Allowance should, of course, be made for the fact that the intermolecular forces have been entirely neglected in this calculation. Thus I concluded that the strange change of state in liquid helium, even though manifested in the fluid and not in the gaseous state, might be due to the same mechanism the skeleton of which is already visible if one simplifies the liquid to the degree that one disregards the forces between the molecules entirely. In some way this peculiar condensation can be described by saying that it represents a kind of ordering process, though not so much with respect to the location of the atoms in space (as happens to be the case for an ordinary condensation or crystallization), but rather with respect to their velocities.

It proved too difficult, however, to substantiate this idea directly by including the effect of the interaction forces in the calculations. Nevertheless, numerous qualitative consequences could be deduced from this interpretation without entering into the details of such difficult calculations; these consequences corroborated a general concept which is now known as the 'two-fluid model' of helium II and which led to a series of predictions of phenomena with liquid helium which were not known at that time but which were afterwards verified by experiments. Probably the farthest reaching implications were discovered by L. Tisza[4]. We met when I was developing the above ideas about the Bose–Einstein condensation and its possible relation to the transformation of liquid helium into superfluid helium. Almost immediately he saw that this picture would imply, among other consequences, a very peculiar heat transport in superfluid helium, entirely different from the cumbersome mechanism by which heat is ordinarily propagated in matter (namely, by heat conduction or convection). It was inferred that heat could go through superfluid helium by way of a new kind of waves very much as sound does, with, however, a different characteristic propagation velocity. The velocity of these peculiar waves would depend on the temperature: it would be zero at 2·19°, would increase to a maximum at about 1·6° abs., and then again decrease for still lower temperatures.

When Tisza made this prediction (1938), practically no one took the theory seriously. It appeared too queer that the mere non-individuality of molecules should have such a very concrete measurable consequence. Thus nobody cared to make an experiment at that time in order to see whether there was any truth in this idea. The War came, most physicists were busy with war physics, and the whole theory was almost forgotten, when in 1941, in Moscow, a similar theory was developed by L. Landau[5], not quite independently of the foregoing development. Yet he contested the idea that the Bose–Einstein statistics had anything to do with the subject—arguing that liquid helium is not a gas, which fact, of course, has never been questioned. Landau's theory was supposed to be based on a quantization of hydrodynamics, but actually it seemed much more to rest on newer measurements with liquid helium, which were made in Moscow by Kapitza at the same time[6]. Some of Kapitza's results had been implied in the predictions Tisza had made three years earlier on the basis of the Bose–Einstein theory. Hence they ought to be considered as confirmations of that theory.

Unfortunately, it was difficult to appreciate Landau's theory, as its theoretical basis appeared quite obscure. On the other hand, it has not been possible so far to develop a rigorous statistical theory of the liquid state which includes both the Bose–Einstein condensation and the interaction forces as well. Yet so far as the measurable phenomena are concerned, the mathematical scheme yielded by either of the two theories, London–Tisza's on one hand, and Landau's on the other, seemed essentially the same. In particular, the new kind of wave propagation appears in Landau's theory also; Landau called the new waves "second sound", not quite appropriately, since it is heat rather than pressure which is being propagated.

But Landau, being close to an excellent low-temperature laboratory, now gave the incentive for further experiments. They were conducted by Peshkov in Moscow near the end of the War[7]. These experiments brilliantly confirmed the existence of the predicted 'second sound', or rather thermal waves, in all details. In particular, they confirmed the values predicted by the theory for the propagation velocity of these peculiar waves for all temperatures measured.

This showed that the equations which described the behaviour of liquid helium II in bulk were essentially correct. Yet it appeared to be an open question whether the original starting point of these ideas, the molecular mechanism of the Bose–Einstein condensation, was essential for the theory.

Quite recently a new possibility has opened for deciding, by experiment, the relevancy of the Bose–Einstein way of counting, without entering into the obscurities of complicated and approximate calculations. Ordinary helium (He^4) has an extremely rare isotope, He^3, which occurs in atmospheric helium, itself a very rare gas, only in a ratio of 1 : 1,200,000. There are very definite reasons, which cannot be explained here, which force the physicist to apply a different way of counting to helium-3 from that used for ordinary helium. According to this particular way of counting, called 'Fermi–Dirac statistics', the helium-3 atoms, at least if they are considered as force-free, would show *no condensation* of the kind derived for 'Bose–Einstein particles'. The manner in which one counts the permutations of 'Fermi–Dirac-particles' does not imply individuality of the molecules either; however, it has a peculiar feature in addition, in that it does not permit several particles of the same kind to have exactly the same velocity. This particular feature of the 'Fermi–Dirac particles' precludes a condensation mechanism of the type encountered for 'Bose–Einstein particles'.

The extreme rarity of helium-3 had prevented experiments with this isotope until recently. Now, appreciable quantities of this isotope can be obtained from the Atomic Energy Commission, since it is one of the many products which can be made by using the strong neutron beams of an atomic pile.

It has recently been possible to liquefy a fraction of a cubic centimetre of pure helium-3 and to measure its vapour pressure curve[1]. The critical temperature and the critical pressure are about 3·34° abs. and 875 mm. mercury respectively.

The experiment in Chicago referred to in the beginning of the present article attacks directly the question of whether or not liquid helium-3 at some temperature in the neighbourhood of 2° abs. becomes superfluid like helium-4. The liquid helium is being pressed through a fine capillary, and one measures the flow velocity at different temperatures. While for liquid helium-4 this flow velocity has, at 2·19° abs., a discontinuity and for lower temperatures suddenly becomes extremely large, the experiments with helium-3 show *no* remarkable change of the flow properties from 3° abs. down to 1·05° abs. The viscosity is of the same order of magnitude as that of liquid helium-4 above 2·19°, and considered as a function of temperature it shows *no discontinuity* in the whole temperature-range measured. This is a negative result, true, still a quite decisive one, since it settles a *qualitative* question. One might hold definite judgment in suspense until the experiment is extended to a still lower temperature. However, the temperature of 1·05° abs. reached so far ought to be quite sufficient to ascertain that the Bose–Einstein condensation mechanism represents the key to the understanding of the unique fluid state represented by helium-4 at temperatures below 2·19°.

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WEATHER AND FARMING IN INDIA

THE world pattern of agriculture is largely determined by the world pattern of climate, and where wide fluctuations from average weather may occur without warning, the results may be catastrophic. Indian fear of flood and drought and of other weather extremes made it imperative that there should be some organised study of weather in relation to crops, and a recently published report* surveys the activities of the Agricultural Meteorology Branch of the India Meteorological Department set up for this purpose in 1932.

The survey is in two sections: the first gives the history of the formation of the Branch, a statement of its objects and a general review of work done up to 1946; the second gives a more detailed account of recent activity. One might reasonably expect to find some indication of the impact of the first sixteen years of work on Indian farming; but the main emphasis is on what was planned, much less on results obtained, and there is none on the application of the results. The report is completed by eleven appendixes, mainly reprints of scientific papers published during the period 1946–48. In the first of these appendixes is a description of the Indian Crop Weather Scheme, and the report notes with natural pride that this scheme was adopted for world use by the International Commission of Agricultural Meteorology at Toronto in 1947. Aiming at the collection of relevant crop and weather data throughout the growing year at a network of stations, the scheme differs only in non-essential details from the British Crop Weather Scheme started in 1922. As this has been as near a failure as human pride will ever admit, it seems a pity that an international conference should agree to a world-wide experiment without first being sure that it can be successfully carried out in at least one place. The British Scheme broke down on the biological side, and in this Indian report there are several hints of difficulties being met in the estimation of "the state of the crop".

An interesting aspect of the work of the Agricultural Meteorological Branch is its attempt to establish a weather service for farmers; when the service has been in operation for some years, a critical account of its running (including failures as well as successes) will be of immense value to agricultural meteorology. Seven regional forecast centres have been set up to issue detailed weather bulletins and warnings to farmers, and the centres are being supplied with "Crop Weather Calendars" showing the life-history of the chief crops of the region, their normal weather requirements, and the abnormal weather for which warnings are necessary at different periods during growth. This experiment might well be tried elsewhere, and even in Great Britain the regional division should be regarded as an essential part of the scheme.

The remainder of the report is largely concerned with the work of the observatory at Poona, set up in 1933. Again the account is mainly of activity, without any attempt at a synoptic survey; but there is an impressive list of research problems being investigated in the main branches of agricultural meteorology, with an understandable emphasis on the physical problems of the heat balance and the water balance of the soil, turbulent diffusion and the

* India Meteorological Department. Report on Agricultural Meteorology up to 1948. Pp. v+38. (Delhi: Manager of Publications, 1948.)

design of new instruments. The 1946–48 section gives more detail than one normally expects in a director's report; but this detail includes some interesting tables of night radiation to cloudy and clear skies, tables of root development and crop growth as a function of depth of water-table, and comparative readings for different types of evaporimeters. It is to be regretted, however, that physicists should waste their time on the Piche and Wild instruments.

Farming is impossible without water, and much of the Poona research is concerned with the hydrological cycle; but there does seem to be a certain lack of self-criticism over fundamentals. An evaporation map of India, calculated in 1934 from an American empirical formula, was still in use in 1946 (Appendix 2). As this shows regions having more than 150 in. evaporation in a year, one feels that the Indian workers themselves might have asked where the necessary latent heat comes from, and to have made some assessment of the meaning and reliability of the estimate; their failure to do so gives a clue to the source of the chief disappointment felt in reading this report. There is little evidence of any integration of the many lines of work—all good in themselves—and while 207 publications in the period look impressive as a total, there are too many snippets and too many repetitions. By decreasing the quantity, a considerable increase in quality could be achieved, and what is good work would become magnificent. It would be a tragedy, in India as elsewhere, if either the Poona workers or the Indian Government came to measure the worth of this very valuable research organisation by the annual number of publications.

H. L. P.

CARNEGIE TRUST FOR THE UNIVERSITIES OF SCOTLAND

THE forty-seventh annual report of the Carnegie Trust for the Universities of Scotland for the year 1947–48 refers to the loss sustained by the death of the chairman of the Trust, Sir Robert B. Greig, on November 29, 1947. He has been succeeded by Sir John Ireland Falconer.

In the field of research, demands for assistance with travel and maintenance grants increased, and the executive granted £4,000 to supplement university funds for assisting professorial and non-professorial staff in this way. Special grants were made to St. Andrews for the purchase of four Bell–Gaumont projectors with accessories; to Glasgow for electrophoresis apparatus for the Department of Biochemistry; to Aberdeen for maintenance of the swimming pool at King's College to permit free use; and to Edinburgh for provision of equipment for linguistic and folk-lore recording in both Gaelic and Scottish areas. Assistance given to students decreased by £7,992 to £43,040, the number of beneficiaries decreasing from 3,068 to 2,368; repayments by former beneficiaries also decreased to £2,634, from fifty-four beneficiaries.

Details of the eighth quinquennial distribution (1947–52) are given in an appendix. They include £33,650 to the St. Andrews Centre, of which £12,000 is for housing for university staff, £5,500 for scientific equipment, mainly for research, and £6,600 for equipment for the Advanced Medical School and £13,350 for University College, Dundee, of which £2,350 also is for scientific equipment, mainly for research. Grants to the Glasgow Centre include £70,000 to the University towards erection of the final portion of the Chemistry Institute, £5,500 to the Royal Technical College for the development of a College library service, £2,500 to the West of Scotland Agricultural College and £3,000 to the Scottish Marine Biological Association for renovating the aquarium at Millport Station. Grants to the Aberdeen Centre include £5,000 to the University for library books, £42,000 towards the cost of a new Chemistry Department, £4,000 for equipment for the Mechanical Engineering Department of Robert Gordon's Technical College, £1,000 each to the North of Scotland College of Agriculture and the Macaulay Institute for Soil Research, and £2,000 to the Rowett Research Institute. Grants to the Edinburgh Centre include £23,000 to the University for library expenditure, £20,000 for a lectureship in phonetics and £25,000 for capital expenditure on the Bush and Dryden estates, £5,000 to the Heriot-Watt College for special equipment in the Mechanical Engineering Department, and £2,000 each to the School of Medicine of the Royal Colleges, the Royal (Dick) Veterinary College and the Edinburgh Dental Hospital and School.

The new scheme for the award of fellowships, scholarships and grants for research is again appended, with details of awards made for the year 1948–49, and a list of publications from beneficiaries during 1947–48. In a note on the work of investigators under the research scheme during the year, reference is made to that of Dr. T. S. Hutchison on the strain sensitivity of magnetic susceptibility, of Mr. F. B. Stern on the crystal structure of tartaric acid, of Mr. E. Reid on the diabetonic principle of the anterior pituitary body, and of Miss D. C. Gibb's progress in her investigations on free-growing fucoid algæ. Dr. C. C. Forsyth has continued an intensive study into the place of free diet in the treatment of diabetus mellitus, Mr. J. B. Wilson his investigations of the rates of absorption of different amino-acids of different molecular weight from the intestine of the rat and cat, and Miss R. M. Campbell her study of the effects of various factors on the structure of the liver.

Work in chemistry has chiefly been a consolidation of earlier studies, but special mention is made of Mr. G. W. Youngson's work on polymerization, in which he has built up, on the basis of the pentaerythritol molecule, remarkable 'cruciform' macromolecules in which four big chains of approximately equal length, built up of alternate glycol and adipic acid residues, radiate from a single carbon atom, and more recently, on the dipentaerythritol and trimethylolpropane molecules as bases, six-rayed star-shaped and 'double-Y-shaped' molecules. Mr. C. T. Dickson has continued to work on the structure of colchicine, and Mrs. Storey and Miss B. Cairns on the synthesis of benzacarboline and methoxybenzcarboline and of benzacridone analogues of mepacrine as of possible interest as anti-malarials.

Dr. A. Lamont's work on the rocks in the Pentland Hills assigned to the Silurian system has led to a tentative opinion that the rocks are of earlier date than has generally been accepted. Dr. F. H. Stewart has proved the presence in the complex of basic rocks at Belhelvie, near Aberdeen, of a type of banding, attributed to gravitational settling, that seems to be paralleled in other parts of the world. The Trust has given important aid in the publication of

Dr. A. E. Trueman and Dr. J. Weir's extensive work on British Carboniferous Non-marine Lamellibranchiata. Mrs. E. M. Knox has continued her work on the spores in coal, Miss D. Elrich, at the University of Budapest, has investigated industrial conditions in Hungary, Mr. Gilfillan the social and economic development of Dumbartonshire in the nineteenth century, and Miss A. M. Keay a study of the Forfeited Estates Papers in H.M. Register House, Edinburgh, with the view of elucidating the effect of the policy of the Commissioners on the social and political organisation of the Highlands during the eighteenth century.

The report of the superintendent of the Laboratory of the Royal College of Physicians, Edinburgh, pays a tribute to the work of Lieut.-Colonel W. F. Harvey, who was in charge of the Histopathology Department for twenty years and whose death on September 11, 1948, was a great loss to the Laboratory. Research on the chemotherapy of cancer using transplantable tumours in mice continued, while in biochemistry the discovery of new chemotherapeutic agents was again a chief objective. Some *p*-phenanthroline compounds proved to have considerable action against avian malaria, and the preparation of chloro derivatives has been completed. Work has also continued on the synthesis of *p*-phenanthroline compounds containing two basic side-chains, and a number of benzthiazole derivatives, chiefly 6-nitro- and 6-amino-2-styryl derivatives, have been prepared for test for antifilarial activity. The synthesis of benzthiazole compounds has been the chief concern of Dr. J. E. McKail.

CHEMOTHERAPY OF TUBERCULOSIS

THE fourth meeting of the Fine Chemicals Group of the Society of Chemical Industry was held at King's College, London, on January 18, with Sir Jack Drummond in the chair. A discussion on "The Approach to the Chemotherapy of Tuberculosis" was opened by papers by Dr. James Walker and Dr. P. M. D'Arcy Hart, both of the National Institute for Medical Research.

Dr. James Walker said that the limited knowledge of the metabolic processes of the tubercle bacillus has made an empirical approach to chemotherapy inevitable; but research has been aided by the use of wetting agents, such as 'Tween 80', and the addition of serum albumin to liquid media, which make it possible to obtain visible growths from minute inocula of the organism. Compounds at present under trial include the sulphones, which probably exert their action in the body by slow hydrolysis to diamino-diphenylsulphone; the diphenylamine *o*-carboxylic acids which act as antioxidants in certain biological oxidation mechanisms, and which have shown some inhibitory activity *in vitro*; and the di-alkylsuccinic acids and other substances with lipophilic terminal groups, which may aid penetration of the drugs into the lipoid-rich bacillus. Various antibiotics have been tried against the tubercle bacillus, the best so far being streptomycin.

Dr. D'Arcy Hart said that sulphetrone and its analogue promizole, the least toxic of the sulphones, have produced some regression in the acute forms of human infection, and calciferol has brought about dramatic and consistent improvements in lupus vulgaris. Streptomycin has proved life-saving in a proportion of cases of tuberculous meningitis and miliary tuberculosis, hitherto invariably fatal, and it is useful in less serious forms of the disease. Its clinical use is limited by its toxicity and by the drug resistance which develops in some patients under treatment. Lastly, *p*-aminosalicylic acid has shown promise and is under trial in Great Britain, both alone and in conjunction with streptomycin.

Much yet remains to be done; but chemotherapy has already given a new edge to the sword of established practice, and the time may not be far off when tuberculosis will cease to be the greatest destroyer of useful lives in Western civilization.

CORRELATION OF EVOLUTION OF HOST AND ECTOPARASITE

UNDER the title "Some Rules in Ectoparasitism", Dr. W. Eichler, of Ascherleben, Germany, contributes an interesting paper to *The Annals and Magazine of Natural History*, Series 12, No. 8 (August 1948). It has long been known that the natural classification of some groups of animals of parasitic habits corresponds with that of their hosts. Since Fahrenholz was one of the chief protagonists of this rule (in regard to the Anoplura in particular), the author has named this general principle "Fahrenholz's Rule". It applies, for example, to certain groups of ectoparasites and their hosts. Fahrenholz argued that the ancestors of extant parasites must have been parasites of their original ancestral hosts, evolution of host and parasite consequently having gone on side by side. The conclusions drawn from the classification and relationships of many groups of parasites enable light to be thrown on the natural relationships of their hosts—even in cases where the latter show very divergent features from other members of their group.

One of the best examples of the working of this principle is in the case of the flamingo—a bird which is placed by some ornithologists among the ducks, whereas others relegate it to the storks. Those who think it to be a duck explain its long stork-like legs as convergence owing to similarity of habit. Others maintain that it is, in fact, merely an aberrant stork, whose duck-like bill is the result of convergence. The evidence afforded by the parasites of flamingoes strongly argues in favour of their derivation from those of ducks. Thus the bird lice show in the main a clear affinity with those living on the Anatidæ. The ostrich and rheas are only parasitized by bird lice and feather mites common to those birds. This evidence is also confirmed by the cestode and nematode parasites of those two groups of birds.

Szidat (1939) has shown in his studies of the life-cycles of Trematoda that primitive hosts are parasitized by primitive types of tremades and specialized hosts by specialized parasites. He quotes the parasites of various vertebrates in support of his contention. In the trematode subfamily Asymphylordorinæ the hosts are fishes of the family Cyprinidæ, which have their developmental centre in East Asia. In this region some of these Trematoda occur among different genera of Cyprinidæ, but with the spread of these fishes to Europe the parasites become more specialized, with the result that they become restricted to a particular Cyprinid genus or, in one case, to a single species.

Dr. Eichler also explains what he calls the "divergence rule". Where there are groups of hosts with many species, he deduces the rule that the more a given host is infested by different genera of parasites the larger must be the group to which that host belongs. This principle is illustrated by many of the Mallophaga that infest large groups of closely related birds. The fact that the tinamon Mallophaga are very numerous in genera is exceptional for the parasites of a bird group containing so few species. It indicates, perhaps, that the Tinamidæ was a much larger group of birds at one time, most of its species having died out.

RESEARCH IN INDUSTRIAL RELATIONS

AT the 1948 mid-winter meeting of the American Philosophical Society, which was held at Philadelphia in February 1948, papers were read dealing with research frontiers in human relations.

One of these papers, by Prof. E. Wight Bakke, of Yale University, dealt with the subject of research into industrial relations and suggested that the search in recent years by leaders of management and labour for basic principles of human relations on which they might build new techniques in their own organisations has been in vain (*Proc. Amer. Phil. Soc.*, **92**, No. 5; Nov. 12, 1948). According to Prof. Bakke the psychologists have come closest to providing the practical men with the most useful principles, and some of them have contributed by the development of tests for prospective employees, attitude surveys, techniques for building morale, training of supervisors, and similar projects. Other psychologists have also undertaken a careful analysis of the motives for and determinants of behaviour among workers themselves. Anthropologists, sociologists and economists, too, have carried out investigations; but these have been only loosely connected with the subject of industrial relations, and no common theory running through this research into human relations has emerged.

It is not surprising, therefore, that the leaders of management and labour have been unable to turn to a dependable and useful science of human relations. Neither is it surprising that the men of action have not been able to find what the men of science have been unable to find or produce, namely, an integrated body of principles of human behaviour on which the techniques for the organisation and direction of human beings in purposeful group activity could be tested and on the basis of which effective action could be developed.

In an attempt to determine the particular type of research into industrial relations in which the development of a scientific theory of human interaction and of the determinants of human behaviour would be the dominating consideration, Prof. Bakke insists that industrial relations are simply one kind of human relations. The principles which govern men's actions and relations in industry are no different basically from those which govern their social, their religious, their familial, their educational, and their political activity and relations. The distinguishing marks of this kind of industrial relations research would be:

(1) The general problem must be defined as one of learning the determinants of human action.

(2) Specific questions must be shaped by reference to the need for amplifying or modifying a basic theory of cause and effect.

(3) Group-wide or group-wise behaviour and the group as an organic entity must be emphasized.

(4) A diagnostic pattern outlining all personal and environmental facts needed for adequate explanations must be utilized.

(5) Attention must be paid to the definition and measurement of data in quantitative terms.

(6) Field observations must be used as the major source of data.

(7) Theory must be progressively formulated and tested in the laboratories of industrial and union operations.

This kind of research may be described as a 'frontier' activity primarily because it is seeking to develop systematic principles of cause and effect in a field of behaviour in which such principles are not understood. Here the most pressing need of to-day is for studies not only of personnel policies but also the nature of persons; not only of incentive systems but also of human incentives; not only of collective bargaining procedures but also of the factors which mould the actions and attitudes of the bargainers; not only of bargaining issues but also of the structures of living of the parties which give them varying and conflicting 'slants' on the issues; not only of the structure of management and unions, but also of the compulsions these structures impose upon the actions and thoughts of the men who represent them; not only of techniques for organising enterprises or unions, but also of the principles of effective association and group solidarity and teamwork.

This type of research raises many problems, in addition to the scientific problems of the research itself. It is expensive. The facts must be gathered through field-work of a comprehensive nature. The personnel who can collect the facts must have a breadth of training and knowledge preferably in more than one discipline. A further difficulty arises out of the necessity for a partnership of the men of science with the men of action, management and trade unionists, in the collecting of facts and the testing of conclusions. Even when co-operation is obtained, there is the necessity for accurate and full reporting of results which are not always easy to reconcile with the requirement for avoiding harm, actual or feared, to the co-operating organisations and individuals. There is also the necessity for using a language in describing scientific results which is understandable to men who are not trained in science.

In conclusion, Prof. Bakke describes the value of theory in the advancement of knowledge and its application to the solution of the world's industrial problems. The increase in quantity and quality of material goods which flow from industrial operations is as dependent on the effective co-ordination of people and efficient team-work as upon the adequacy of tools and technique. The processes of democratic society are seriously disturbed by industrial warfare. The practical decisions in ordering human relations so that the public interest may be met depend on the leaders of industry and unions. Changes in technology, in economic, social and political situations, are constantly inserting elements, of which the old techniques took no account, into the problem. To-day, more than formerly, he is poorly equipped for adaptive action, in industry or elsewhere, who knows merely what to do but not why he does it.

T. H. HAWKINS

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 2

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5.30 p.m.—"As Seen by Denmark" (Sound films with introduction by Dr. Ingolf Boisen).

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. Bernard Payne: "Air Lift Pumping".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. F. J. Cole, F.R.S.: "Aspects of Biological Discovery, 1, Spontaneous Generation".*

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Capt. H. Topley: "Navigation at Sea" (Science and Marine Navigation, 4).

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Annual General Meeting; Mr. M. P. Balfe: "Leather—the Scientific Background to a Traditional Industry".

Tuesday, May 3

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Annual General Meeting; Dr. L. E. Ryall: "The Scientific Work of the Post Office".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. M. Grace Eggleton: "Physiological Properties of Ethyl Alcohol".* (Further Lectures on May 10 and May 17.)

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. G. W. O. Howe: "Some Electromagnetic Problems".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. J. McConnell: "Function Space and Applied Mathematics".* (Further Lectures on May 4 and May 6.)

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Scientific Approach to Human Problems in Industry" (to be opened by Sir Frederick Bartlett, F.R.S., Mr. Alec Rodger and Dr. Elliott Jacques).

Wednesday, May 4

ROYAL SOCIETY OF MEDICINE, HISTORY OF MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 4.30 p.m.—Annual General Meeting; Dr. E. Ashworth Underwood: "To Edward Jenner on his 200th Birthday" (Presidential Address).

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, May 5

UNIVERSITY OF LONDON (at Wye College, Ashford, Kent), at 5.15 p.m.—Prof. G. E. Blackman: "Modern Methods of Weed Control".*

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. F. E. Rowland: "Some Aspects of Agricultural and Horticultural Electrification in the United States".

ROYAL METEOROLOGICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 6 p.m.—Mr. E. Gold, F.R.S.: "Meteorology in the First World War".*

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-WESTERN SECTION (in the Reynolds Hall, College of Technology, Manchester), at 6.45 p.m.—Mr. W. G. Roberts: "Ceramic Capacitors".

Friday, May 6

PHYSICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 4.30 p.m.—Annual General Meeting; at 5 p.m.—Prof. G. I. Finch, F.R.S.: Presidential Address.

GEOLOGISTS' ASSOCIATION (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. P. E. Kent: "A Structure Contour Map of the Pre-Permian Rocks of England and Wales".

Friday, May 6—Saturday, May 7

BRITISH RHEOLOGISTS' CLUB (joint meeting with the Local Section of the CHEMICAL SOCIETY, at the Washington Singer Laboratories, University College, Exeter), at 9.45 a.m.—Discussion on "Suspensions and Sedimentation".

Saturday, May 7

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University Museum, Oxford), at 1 p.m.—Scientific Papers.

LINNEAN SOCIETY OF LONDON (at the Herbarium, Royal Botanic Gardens, Kew), at 2.30 p.m.—Demonstration: "Botanical Taxonomy after Linnaeus".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENCE OFFICER, Directorate, Shanghai—The Director, Personnel Department, British Council, 3 Hanover Street, London, W.1 (May 7).

SENIOR LECTURER or LECTURER IN CYTOLOGY, and a SENIOR LECTURER or LECTURER IN GENETICS—The Registrar, The University, Manchester 13 (May 7).

MECHANICAL and AERONAUTICAL ENGINEERS (unestablished Senior Scientific Officer grade) with experience in airframe stressing and design calculations or in the design and development of small mechanical components, at Royal Aircraft Establishment, Farnborough, and other Ministry of Supply Establishments in South England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.882/48A (May 7).

SENIOR LECTURER IN MECHANICAL ENGINEERING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (May 7).

LECTURER IN PHILOSOPHY—The Registrar, King's College, Newcastle-upon-Tyne (May 7).

PHYSICAL CHEMISTS as Scientific Officers at a Ministry of Supply Research and Development Establishment near London, for duties in (*a*) high temperature refractories, (*b*) crystallography and practical microscopy, (*c*) spectrography, and (*d*) plant development—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.1025/48A (May 10).

WELLCOME RESEARCH FELLOWSHIP in veterinary science or practice—Dr. W. R. Wooldridge, Animal Health Trust, 232–235 Abbey House, Victoria Street, London, S.W.1 (May 14).

LECTURERS (2) IN FUEL TECHNOLOGY, an ASSISTANT LECTURER IN PHYSICS, and an ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, The University, Sheffield (May 14).

LECTURER or ASSISTANT LECTURER IN GENETICS, a LECTURER IN BOTANY (preferably with Morphology or Ecology as a special interest), an ASSISTANT LECTURER IN PLANT PHYSIOLOGY, and an ASSISTANT LECTURER IN GEOGRAPHY—The Secretary of University Court, The University, Glasgow (May 14).

LEVERHULME STUDENTSHIPS IN CHEMICAL ENGINEERING—The Secretary, University College, Gower Street, London, W.C.1 (May 15).

FELLOWSHIP AND SCHOLARSHIP for session 1949–1950—The Secretary, British Institute of Archæology at Ankara, 56 Queen Anne Street, London, W.1 (May 16).

LECTURER and an ASSISTANT LECTURER IN THE DEPARTMENT OF ZOOLOGY, a LECTURER IN INDUSTRIAL HYGIENE and a RESEARCH ASSISTANT IN SOCIAL MEDICINE IN THE DEPARTMENT OF SOCIAL AND INDUSTRIAL MEDICINE—The Registrar, The University, Sheffield (May 21).

CHIEF OF DIVISION OF ELECTROTECHNOLOGY, National Standards Laboratory, Sydney (Ref. No. 2208), a SENIOR RESEARCH OFFICER on the Editorial Staff of the Council for Scientific and Industrial Research, Melbourne (Ref. No. 2188), and a RESEARCH OFFICER, Division of Plant Industry, Hobart (Ref. No. 2068)—The Chief Scientific Liaison Officer, Australian Scientific Research Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (May 21).

SENIOR LECTURER IN PSYCHOLOGY (General Psychology with special emphasis on Educational Psychology) in the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 30).

SENIOR LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, May 31).

ASSISTANT LECTURERS or LECTURERS IN PURE MATHEMATICS, APPLIED MATHEMATICS, CIVIL ENGINEERING, MECHANICAL ENGINEERING, AGRICULTURAL ORGANIZATION and ECONOMICS, and AGRICULTURAL CHEMISTRY, at the Gordon Memorial College, Khartoum—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (June 1).

LECTURER IN PHYSICS (in Pietermaritzburg), a LECTURER IN EXPERIMENTAL PHYSICS (in Durban), and a LECTURER IN BOTANY (in Pietermaritzburg), in the University of Natal—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 15).

SENIOR RESEARCH OFFICER-CHEMIST, and a RESEARCH OFFICER-CHEMIST, in the Paint Industries' Research Institute of the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 30).

TECHNICIAN FOR THE PHYSIOLOGY DEPARTMENT—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

LECTURER IN DAIRYING, and ASSISTANT LECTURERS IN AGRICULTURAL CHEMISTRY and GENETICS, at the School of Agriculture, Sutton Bonington, Loughborough—The Registrar, The University, Nottingham.

GRADUATE (preferably with research experience in biochemistry or chemistry) to assist in investigations on intermediary metabolism—The House Governor and Secretary, Royal Cancer Hospital, Fulham Road, London, S.W.3.

LECTURER IN BOTANY (with special reference to plant metabolism), ASSISTANT LECTURERS IN GEOGRAPHY (with special qualifications in Political Geography) and MATHEMATICS, and DEMONSTRATORS IN BOTANY (*a*) with one year's experience of research in mycology, (*b*) with one year's experience of research in bacteriology—The Registrar, The University, Nottingham.

CEREALIST by the Government of Iraq for the Directorate-General of Agriculture—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.18187.3F.

ASSISTANT PROFESSOR OF ANATOMY—The Dean of Medicine, University of Alberta, Edmonton, Alberta, Canada.

LABORATORY STEWARD—Prof. I. Manton, Department of Botany, The University, Leeds 2.

PHYSICAL CHEMIST or METALLURGIST for work in connexion with both laboratory and practical studies of various aspects of iron-making processes—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Iron Making'.

LECTURER IN CHEMISTRY—The Principal, Royal Technical College, Salford 5.

DIRECTOR OF THE WEST AFRICAN BUILDING RESEARCH ORGANIZATION—The Under-Secretary of State, Colonial Office (Research Department), Sanctuary Buildings, Great Smith Street, London, S.W.1.

HEAD OF THE DEPARTMENT OF FLIGHT—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks.